ALTERNATIVE STRATEGIES DEVELOPMENT REPORT

Preparation of a Strategic Comprehensive Habitat Restoration Plan for the Onondaga Lake Watershed

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U.S. Army Corps of Engineers, Buffalo District

1776 Niagara Street
Buffalo, New York 14207-3199

Prepared By:

P a r s o n s

290 Elwood Davis Road, Suite 312
Liverpool, New York 13088
Phone: (315) 451-9560
Fax: (315) 451-9570

Flora & Fauna
Ecological Consultants
5129 Breeds Road
Moravia, New York 13118
Phone: (315) 497-9332

Quantitative Environmental Analysis
290 Elwood Davis Road
Liverpool, New York 13088
Phone: (315) 453-9009
Fax: (315) 451-9010

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AMP	Ambient Monitoring Program
BMP	Best Management Practices
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FEMA	Federal Emergency Management Agency
FISRWG	Federal Interagency Stream Restoration Working Group
GIS	Geographic Information Systems
HRT	Habitat Restoration Team
NHP	Natural Heritage Program
NHD	National Hydrography Dataset
NLCD	National Land Cover Data
NRCS	National Resource Conservation Service
NWI	National Wetland Inventory
NYSDEC	New York State Department of Environmental Conservation
QA/QC	Quality Assurance/Quality Control
QEA	Quantitative Environmental Analysis
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SCHRP	Strategic Comprehensive Habitat Restoration Plan
SPDES	State Pollution Discharge Elimination System
SVA	Stream Visual Assessment
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

SECTION 1

INTRODUCTION

1.1 PROJECT DESCRIPTION

Parsons has been retained by the United States Army Corps of Engineers (USACE), Buffalo District to prepare a Strategic Comprehensive Habitat Restoration Plan (SCHRP) for the Onondaga Lake watershed. The intent of the plan is to evaluate the inherent capability of the Onondaga Lake watershed to support fish and wildlife and to develop alternative conceptual strategies for improving aquatic, wetland, floodplain, and terrestrial habitats using sound ecological principles. This section provides an overview of the tasks that have been or will be performed to facilitate development of the SCHRP.

The first project task involved the preparation of an *Engineering & Design Quality Control Plan* (Parsons, 2003). The purpose of that report was to provide quality assurance/quality control (QA/QC) procedures for the execution of the project scope of work.

The second project task involved the collection, compilation, review, and analysis of existing information (1970 to present) pertinent to the development of a SCHRP for the Onondaga Lake watershed. This task included identification of data gaps to be utilized as a caveat towards habitat restoration recommendations that will be presented in the SCHRP. The information gathered during the second task was presented in the *Outline of Findings and Data Gaps Report* (Parsons *et al.*, 2003a).

The third task included development of general habitat restoration goals and objectives for aquatic, wetland, floodplain, and terrestrial habitats within the Onondaga Lake watershed based on findings of the literature review, input from the Habitat Restoration Team (HRT), and input from the public (Parsons *et al*., 2003b). Under this task, criteria were developed to assess the relative condition of aquatic, wetland, floodplain, and terrestrial habitat within the watershed.

Task four, the subject of this report, includes: 1) the identification of dominant habitat types within the watershed, 2) the identification of general types of habitat impairments, and 3) the development of alternative conceptual strategies for mitigating the impairments, thus improving aquatic, wetland, floodplain, and terrestrial habitats within the watershed.

The final report, SCHRP, will incorporate the contents of each preceding report and will provide an overview of current habitat restoration projects, programs, and/or initiatives within the watershed. In addition, the SCHRP will identify the opportunities, limitations, and potential funding sources for implementing the restoration strategies developed in task four. The SCHRP will provide an overview of habitat conditions within the Onondaga Lake watershed and will serve as a resource document for identifying future site-specific habitat restoration efforts. The SCHRP will provide a framework for establishing and prioritizing short- and long-term plans for habitat restoration within the watershed.

1.2 OVERVIEW OF ONONDAGA LAKE WATERSHED

The Onondaga Lake watershed encompasses approximately 288 square miles (746 square kilometers; based on the current USGS boundary), is located almost entirely within Onondaga County, and includes rural, agricultural, and urban areas. The watershed area has been updated based on the current GIS layers that have refined boundaries. The watershed includes six natural tributaries: Nine Mile Creek, Harbor Brook, Onondaga Creek, Ley Creek, Bloody Brook, and Sawmill Creek; and two constructed (i.e., man-made) tributaries: Tributary 5A and the East Flume. Onondaga Lake also receives effluent from the Metropolitan Syracuse Wastewater Treatment Plant located along the southeastern shore of the lake. The outlet of Onondaga Lake flows north to the Seneca River, which combines flow with the Oneida River to form the Oswego River, which ultimately discharges into Lake Ontario.

SECTION 2

IDENTIFICATION OF HABITAT TYPES

This section describes the identification of the dominant habitat types within the Onondaga Lake watershed using available literature resources and mapping techniques. Identification of habitat types facilitates the identification of habitat impairment categories and development of alternative conceptual strategies for improving impaired habitats.

2.1 DISTRIBUTION OF MAJOR HABITAT CLASSIFICATIONS

The four major geographic land classifications are Lacustrine (lakes and ponds), Riverine (rivers and streams), Palustrine (wetlands), and Terrestrial (dry land). These land classifications were mapped by overlaying existing geographic information system (GIS) layers for the National Hydrograph Dataset (NHD), the National Wetland Inventory (NWI), the New York State Department of Environmental Conservation (NYSDEC) Freshwater Wetlands, and National Land Cover Data (NLCD) and are shown in Figure 2.1. These map sources are typically produced by interpretation of aerial photographs combined with limited ground truthing. Therefore, additional ground truthing would be required to verify lacustrine, riverine, wetland, or terrestrial boundaries at any specific location.

2.2 DISTRIBUTION OF AQUATIC COMMUNITIES

Aquatic communities were identified within the watershed based on the NHD dataset and elevational data from the Digital Elevation Map (Figure 2.2). The watershed is divided into five subwatersheds, and each subwatershed further divided into stream segments. Streams were then classified according to Edinger *et al.* (2002) using stream order and topography. Lakes were classified based on their use; ponds were generally classified as cultural and natural due to insufficient information to place them in an exact category.

2.3 DISTRIBUTION OF WETLAND AND TERRESTRIAL COMMUNITIES

Dominant wetland and terrestrial communities within the watershed were identified by overlaying existing GIS map layers for wetlands (NWI) and land use/cover types (NLCD) and then re-interpreting and re-labeling these classifications according to Edinger *et al.* (2002). The dominant wetland and terrestrial habitat types present within the Onondaga Lake watershed are depicted in Figure 2.3. The re-interpretation of the wetland and land use/cover type maps was aided by comparison of these maps to supplementary information from other GIS layers, web sources, and published literature. The supplemental GIS layers utilized included NYSDEC Freshwater Wetlands maps, United States Geological Survey (USGS) Digital Raster Graphics Quadrangles, and NYS GIS Clearinghouse One-Meter-Wide Digital Orthoimagery. Web sources included aerial photographs obtained from the USGS Terraserver (http://terraserver_usa.com) and NLCD land use definitions obtained from the United States Environmental Protection Agency (USEPA) Multi-Resolution Land Characteristics Consortium (http://www.epa.gov/mrlc/classification.html). Literature sources included the United States

Department of Agriculture (USDA) Onondaga County Soil Survey (1973), Edinger *et al.* (2002), Reschke (1990), Rhodes & Alexander (1980), and Vandruff & Pike (1992).

A comprehensive list and general description of habitat types known or potentially present within the watershed are listed in Table 2.1. However, the distribution of some categories could not be determined due to unavailable, limited or ambiguous data. Categories, for which this was the case, were not included in Figure 2.3 and were marked as data gaps in Table 2.1. NWI and NLCD map categories were compared against Edinger *et al.* (2002) communities as a means to combine the remaining habitat types into larger dominant habitat types for the watershed. This comparison resulted in the identification of eleven dominant wetland and terrestrial habitat types within in the Onondaga Lake watershed. These habitats are shown in Figure 2.3. A more detailed description of these comparisons is provided in the following paragraphs.

NWI maps were used to identify the boundaries of emergent marshes, shrub swamps, evergreen forested wetlands, and deciduous forested wetlands within the watershed. The NWI emergent marsh areas correspond to Edinger *et al.* (2002) deep or shallow emergent marsh communities. Deep and shallow emergent marshes were mapped as one group in Figure 2.3. NWI shrub swamps correspond to Edinger *et al.* (2002) shrub swamp. NWI evergreen-forested wetlands, within the Onondaga Lake watershed, correspond to hemlock-hardwood swamps. NWI deciduous forested wetlands, within the watershed, are predominantly comprised of one or more the following Edinger et al (2002) communities: red-maple-hardwood swamp, silver maple-ash swamp, or floodplain forest. In Figure 2.3, these three communities are mapped as one group.

The NLCD map lists two land cover categories called row crops and pasture/hay. Row crops are defined as areas used for the production of crops such as corn soybeans, vegetables, tobacco, and cotton. Pasture/hay is defined as areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops. Within the watershed, the combination of these two categories corresponds to the following Edinger *et al.* (2002) communities: cropland/row crops, cropland/field crops, and pastureland. In Figure 2.3, these three communities are mapped as one group and are named “cultivated land or pasture”.

The NLCD map lists deciduous forest as a land cover category. These forested areas are dominated by trees where 75% or more of the tree species shed foliage in response to seasonal change. Within the watershed, these forests are dominated by one or more of the following Edinger *et al.* (2002) communities: Appalachian oak-hickory forest, beech-maple mesic forest, successional northern hardwood, or successional southern hardwood. In Figure 2.3, these four communities are mapped as one group.

The NLCD map lists evergreen forest as a land cover category. These forested areas are dominated by trees where 75% or more of the tree species maintain their leaves year round. Within the watershed, these evergreen forests are dominated by one or more of the following Edinger *et al.* (2002) communities: successional red cedar woodland, pine plantation, spruce/fir plantation, or conifer plantation. In Figure 2.3, these four communities are mapped as one group.

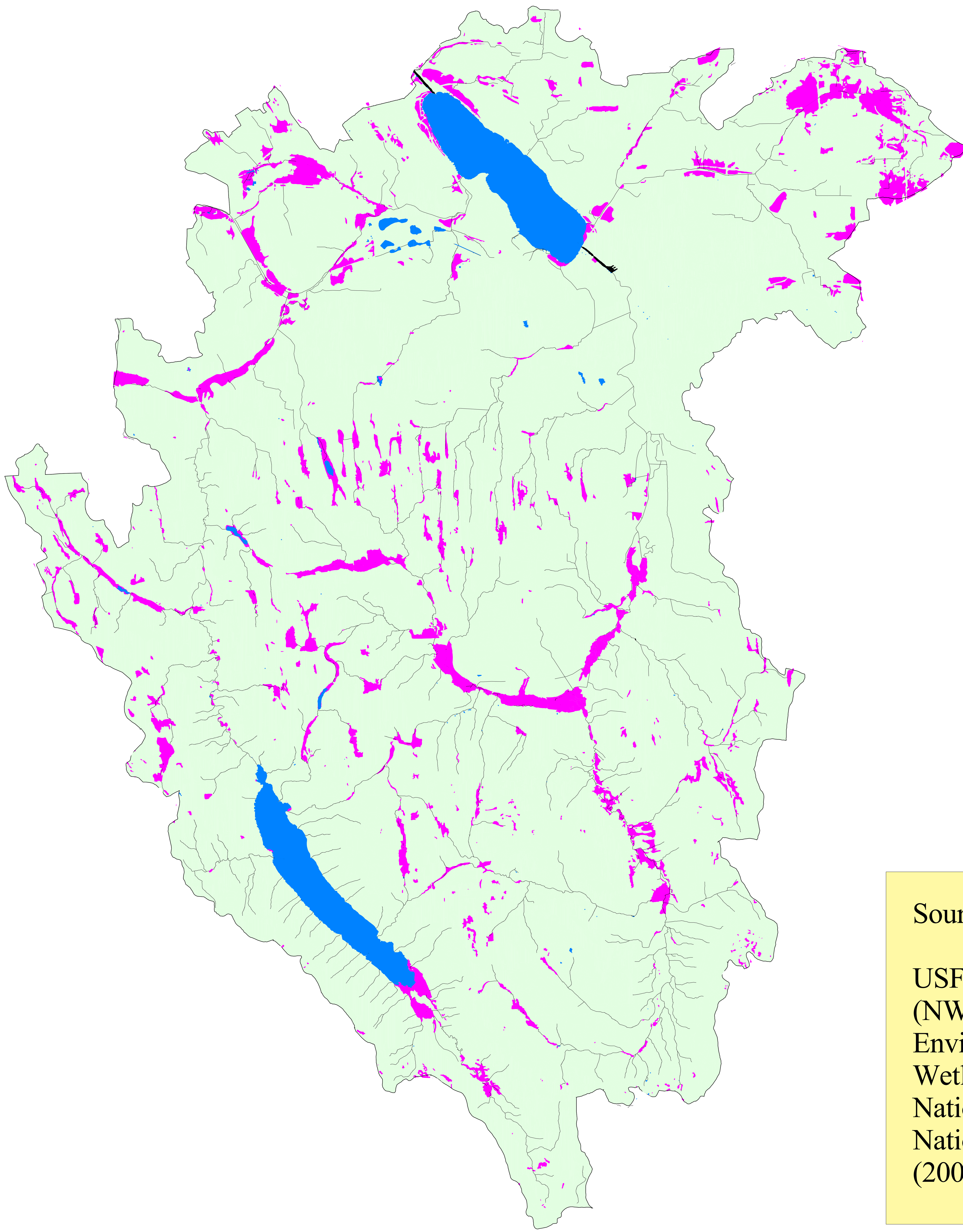
The NLCD map lists mixed forest as a land cover category. These forested areas are dominated by trees where neither deciduous nor evergreen species represent more than 75% of the canopy cover. Within the watershed, these mixed communities are dominated by one or more of the following Edinger *et al.* (2002) communities: Appalachian oak-pine forest, hemlock-northern hardwood forest, or pine-northern hardwood forest. In Figure 2.3, these three communities are mapped as one group.

The NLCD map lists a land cover category called quarries, strip mines, and gravel pits. Within the watershed, these areas were found to consist of the Edinger *et al.* (2002) community called gravel mines.

The NLCD map lists two categories, low intensity residential and high intensity residential, which range from 20 to 80% impervious cover. The combination of these two categories corresponds to the Edinger *et al.* (2002) communities' mowed lawn with trees and mowed lawn and is mapped as such in Figure 2.3.

The NLCD map lists a category called commercial, industrial, and transportation. This category corresponds to the Edinger *et al.* (2002) communities: urban structure exterior, urban vacant lot, and paved roads. In Figure 2.3, these three communities are mapped as one group.

The NLCD map was created in 1992 and the NWI maps were based on aerial photographs taken in 1978, 1981, or 1986. Prior to the final SCHRP, the habitat map will be spot checked for accuracy using year 2002 aerial photographs provided by Pictometery International (Rochester, NY). In addition, an information request has been sent to the NYS Natural Heritage Program (NHP) for updated Onondaga Lake watershed information on any recent land use mapping; rare & endangered species; a list of habitat community types, significant natural communities; wildlife management areas; and state parks. Any updated information obtained will be presented in the final SCHRP.



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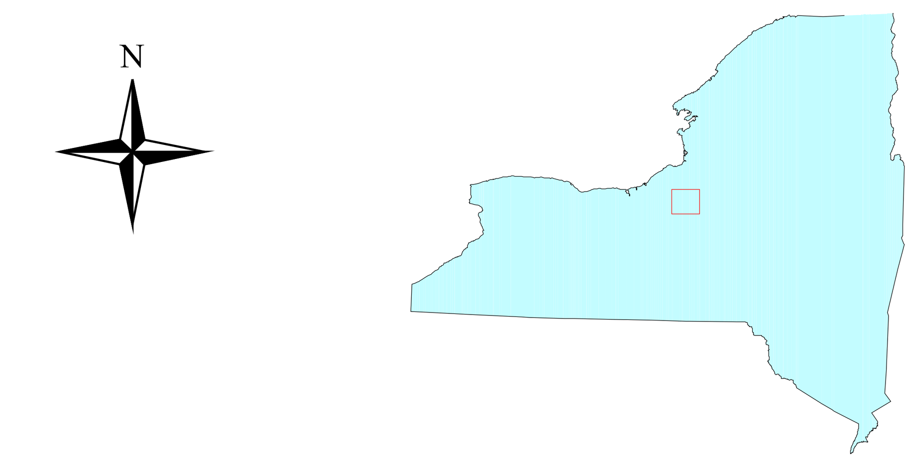

Scale

3 0 3 6 Kilometers

Legend

Habitat Classification

- Lacustrine
- Riverine
- Palustrine
- Terrestrial

Sources:

USFWS National Wetland Inventory (NWI) Maps, NYS Department of Environmental Conservation (DEC) Wetlands in Onondaga County, National Land Cover Data (NLCD), National Hydrograph Dataset, Edinger (2002) and Cowardin (1979)

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Figure 2.1 Distribution of Major Habitat Classifications within the Onondaga Lake Watershed

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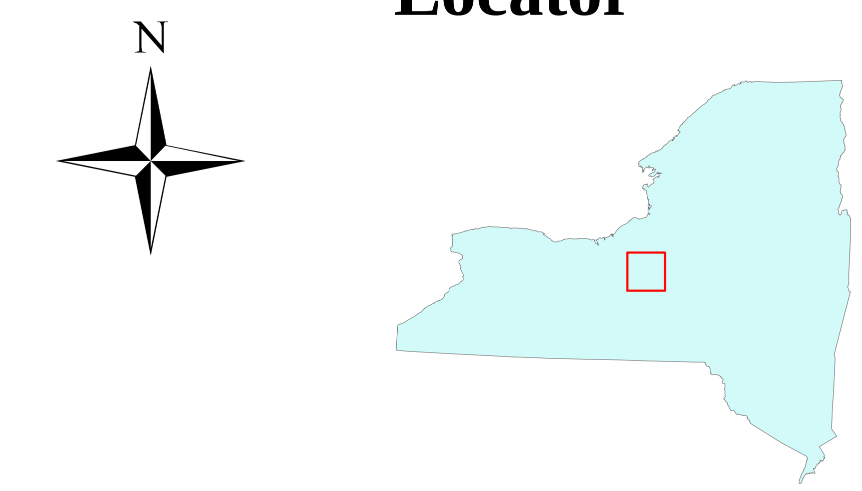

Scale

0 3 6 Miles

Legend

- Stream Segments
- Subwatershed Boundaries

Ecological Community

- Unconfined River
- Confined River
- Rocky Headwater Stream
- Marsh Headwaters Stream
- Canal
- Otisco Lake Watershed
- Industrial Effluent Stream
- Natural Pond
- Reservoir
- Eutrophic Dimictic Lake - Onondaga Lake
- Mesotrophic Dimictic Lake - Otisco Lake

Note: Edinger aquatic habitat communities, stream segments and subwatershed boundaries of the Onondaga Lake Watershed.

Note:

OL = Onondaga Lake
BB = Bloody Brook
LC = Ley Creek
HB = Harbor Brook
OC = Onondaga Creek
NM = Nine Mile Creek

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Figure 2.2
Aquatic Habitat Communities Within the Onondaga Lake Watershed.

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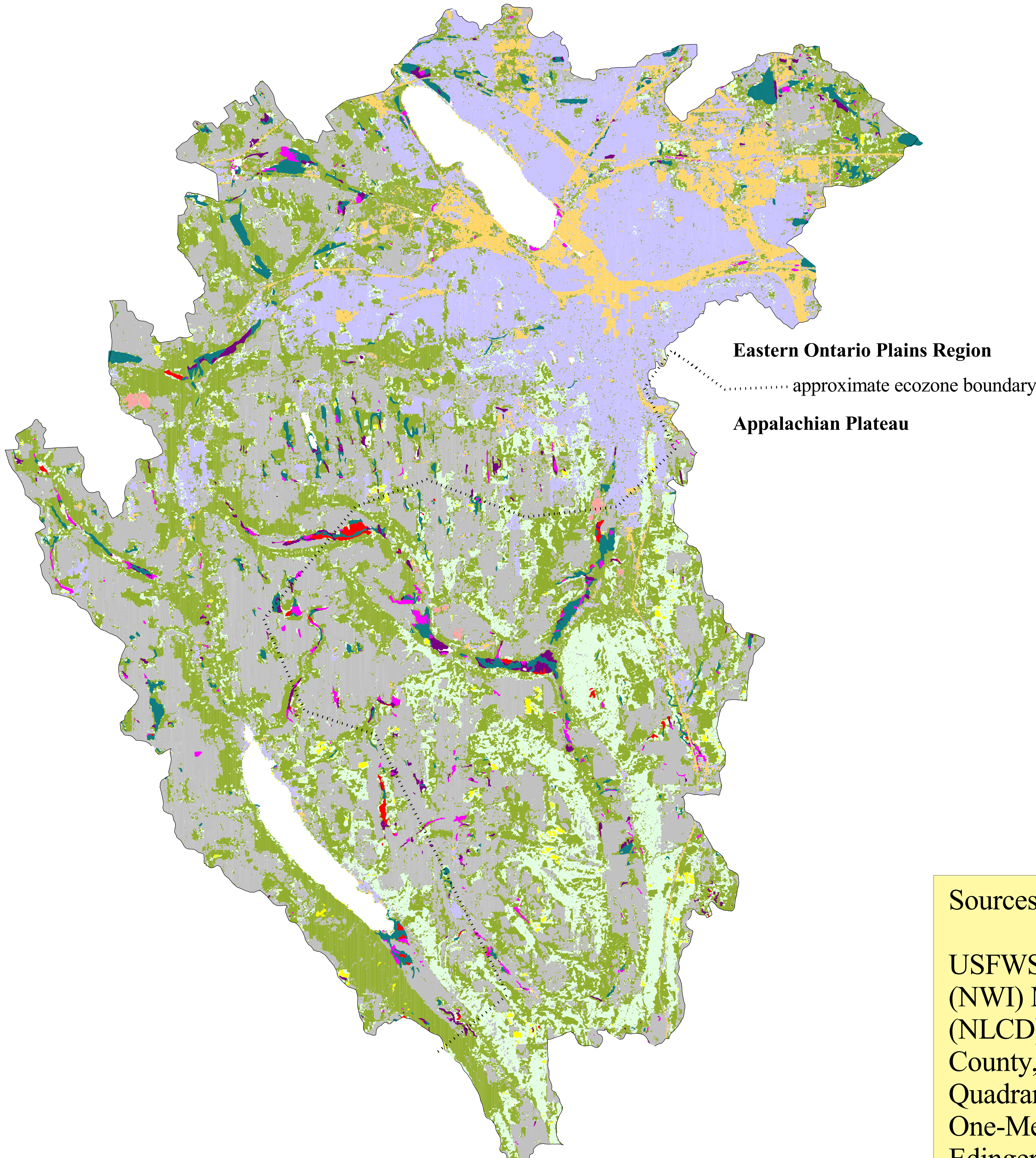

Sources:

USFWS National Wetland Inventory (NWI) Maps, National Land Cover Data (NLCD), USDA Soil Survey for Onondaga County, USGS Digital Raster Graphics Quadrangles, NYS GIS Clearinghouse One-Meter Wide Digital Orthoimagery, Edinger (2002), Reschke (1990), and Vandruff & Pike (1992).

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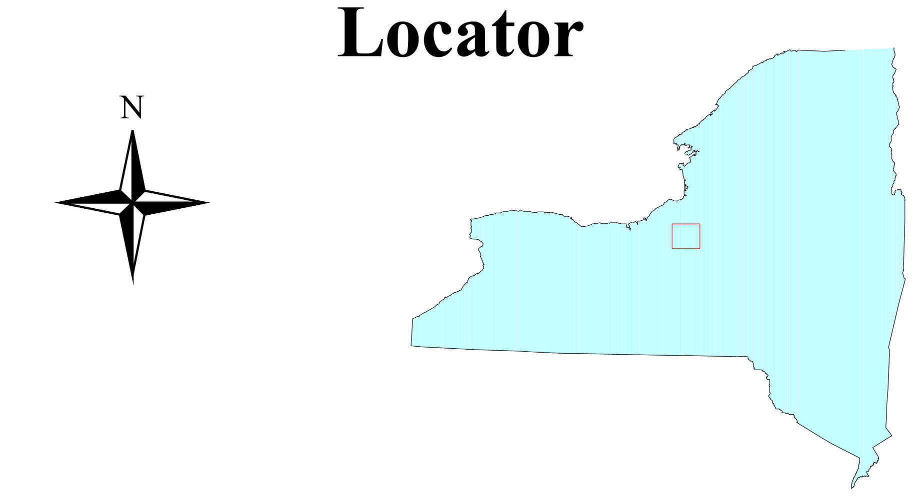

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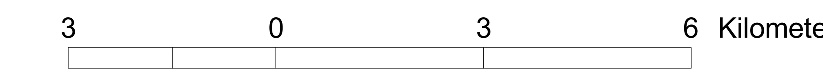

Legend

Ecological Community

- deep or shallow emergent marsh
- shrub swamp
- deciduous forested wetland (red maple hardwood swamp or silver maple-ash swamp)
- evergreen forested wetland (hemlock - hardwood swamp)
- cultivated land or pasture
- deciduous forest (predominantly oak-hickory in the Ontario Plains and predominantly beech-maple in the Applachian Plateau) this category also includes southern and northern successional hardwood forests)
- evergreen forest (successional red cedar woodland, pine plantation, spruce/fir plantation, or conifer plantation
- mixed deciduous & evergreen forest (Applachian oak-pine forest, hemlock-northern hardwood forest, or pine-northern hardwood forest)
- gravel mines
- mowed lawn or mowed lawn with trees
- urban structure exteriors, vacant lots, and paved roads

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Figure 2.3 Dominant Wetland and Terrestrial Habitat Communities within the Onondaga Lake Watershed

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CLASSIFICATION	SUBCATEGORY	ECOLOGICAL COMMUNITY	DESCRIPTION	MAPPED YES	MAPPED NO	Data Gap1	COMMENTS
Lacustrine	Natural Lakes and Ponds	Eutrophic Dimictic Lake	The aquatic community of a nutrient-rich lake that occurs in a broad, shallow basin (i.e., Onodaga Lake).	x			
		Oligotrophic Pond	The aquatic community of a small, shallow, nutrient poor pond.	x			Mapped as natural pond
		Eutrophic Pond	The aquatic community of a small, shallow, nutrient rich pond.	x			Mapped as natural pond
	Lacustrine Cultural	Quarry Ponds	The aquatic community of an excavated basin that is created as part of a rock quarrying, gravel mining or other soil burrowing operation.	x			
		Farm Pond/Artificial Pond	The aquatic community of a small pond constructed on agricultural to residential property.			x	These habitat types were not identified on the current maps but may occur throughout the watershed.
		Reservoir/Artificial Impoundment	The aquatic community of an artificial lake created by impoundment of a river with a dam.	x			This habitat type also includes drinking water reservoirs.
		Artificial Pool	The artificial community of a small pool that is constructed for recreational activities or as a decorative element in a landscape.			x	This habitat type was not identified on the current maps but may occur throughout the watershed.
Riverine	Natural Streams	Rocky Headwater Stream	The aquatic community of a small to moderate sized rock/stream with a moderate to steep gradient, and cold water that flows over eroded bedrock in the area where a stream originates.	x			
		Marsh Headwater Stream	The aquatic community of a small, marshy perennial stream with low gradient, slow flow rate, and cool to warm water that flows through a marsh or swamp where the stream originates.	x			
		Confined River	The aquatic community of relatively fast flowing sections of streams with a moderate to gentle gradient. Confined rivers have a well defined pattern of alternating riffles, pools, and runs. These streams usually represent a network of 3rd to 4th order stream segments.	x			
		Unconfined River	The aquatic community of large, quiet, base level sections of streams with a very low gradient. Unconfined rivers are typically dominated by runs with interspersed pool sections and few short or no riffle segments. These streams typically represent a network of 5th to 6th order stream segments.	x			
	Riverine Cultural	Industrial Effluent Stream	The aquatic community of a stream or a small section of a stream in which the temperature, chemistry, or transparency of the water is significantly modified by discharge of effluent from an industrial, commercial, or sewage treatment plant.	x			
		Canal	The aquatic community of an artificial waterway or modified stream channel constructed for inland navigation or irrigation.	x			
		Ditch/Artificial Intermittent Stream	The aquatic community of an artificial waterway constructed for drainage or irrigation of adjacent lands.		x		These habitat maps were identified throughout the watershed and are located predominantly adjacent to roadways but are not included as dominant habitat types

CLASSIFICATION	SUBCATEGORY	ECOLOGICAL COMMUNITY	DESCRIPTION	MAPPED YES	MAPPED NO	Data Gap1	COMMENTS
Palustrine	Open Mineral Soil Wetlands	Emergent Marsh	A marsh community that occurs on mineral soils or fine-grained organic soils with water depths ranging from 6.6 feet to surface saturation.	x			The areas mapped as emergent marsh include both deep and shallow emergent marshes.
		Shrub Swamp	An inland wetland dominated by shrubs.	x			Species composition can be quite variable.
	Open Peatlands	Inland Salt Marsh	A wetland formed in association with inland salt springs.		x		Inland salt marshes are present within the watershed, but their location is considered sensitive information by the NHP and, therefore, they are not identified in Figure 2.3.
		Marl Fen	A groundwater fed wetland in which the substrate is a marl bed deprived from either lacustrine marl deposits or actively accumulating marl that is exposed at the ground surface		x	x	
		Rich Graminoid Fen	A groundwater fed peatland in which the substrate is predominantly a graminoid peat that may or may not be underlain by marl.		x	x	
		Rich Shrub Fen	A groundwater fed peatland in which the substrate is a woody peat, which may or may not be underlain by marl or limestone bedrock.		x	x	
		Inland Poor Fen	A groundwater fed peatland that occurs inland from the coastal plain in which the substrate is peat composed primarily of Sphagnum, with mixtures of grass-like or woody peat.		x	x	
		Dwarf Shrub Bog	A rain fed or weakly groundwater fed peatland dominated by low-growing, evergreen, heath family shrubs and peat mosses.		x	x	
		Highbush Blueberry Bog Thicket	A rain fed or weakly groundwater fed peatland dominated by tall, deciduous shrubs and peat mosses.		x	x	
	Palustrine Cultural	Reedgrass/Purple Loosestrife Marsh	A marsh that has been disturbed by draining, filling, road salts, etc., in which reedgrass (also known as Phragmites) or purple loosestrife has become dominant.	x		x	This habitat type is quite common within the urbanized portions of the watershed and is included within the mapping of the emergent marsh category in Figure 2.3; however, the boundaries of this habitat type represent a data gap.
		Reverted Drained Muckland	A wetland with muck soils that has been drained and cultivated, and subsequently allowed to flood and revert to a wetland.		x	x	
		Impounded Marsh	A marsh (with less than 50% cover of trees) in which the water levels have been artificially manipulated or modified, often for the purpose of improving waterfowl habitat.		x	x	
		Impounded Swamp	A swamp (with at least 50% cover of trees) where the water levels have been artificially manipulated or modified, often for the purpose of improving waterfowl habitat.		x	x	
		Dredge Spoil Wetland	A wetland in which the substrate consists of dredge spoil; reedgrass is a characteristic species.		x	x	

CLASSIFICATION	SUBCATEGORY	ECOLOGICAL COMMUNITY	DESCRIPTION	MAPPED YES	MAPPED NO	Data Gap1	COMMENTS
Palustrine	Palustrine Cultural	Mine Spoil Wetland	A sparsely vegetated wetland in which the substrate consists of mine spills.		x	x	
		Water Recharge Basin	The aquatic community of a constructed depression near a road or development that receives runoff from paved surfaces and allows the water to percolate through to the groundwater.		x	x	
	Forested Mineral Soil Wetlands	Red Maple-Hardwood Swamp	Red maple swamps are hardwood swamps that occur in poorly drained depressions, usually on inorganic soils.	x			See Section 2.3 for explanation of mapping red maple-hardwood swamp, silver maple-ash swamp and floodplain forest as one habitat type.
		Silver Maple-Ash Swamp	Silver maple swamps are hardwood basin swamps that typically occur in poorly drained depressions or along the borders of large lakes, and less frequently in poorly drained soils along rivers.	x			
		Floodplain Forest	Floodplain forests are hardwood forests that occur on mineral soils on low terraces of river floodplains and river deltas. Floodplain forests are characterized by their flooding regime and not by their species composition.	x			
		Hemlock-Hardwood Swamp	Hemlock-hardwood swamps receive groundwater discharge, typically in areas where the aquifer is a basic or acidic substrate.	x			Hemlock swamps represent the only evergreen type swamp within the watershed. Therefore, evergreen forested wetlands identified on NWI maps were interpreted as hemlock swamps.
		Vernal Pool	An aquatic community of one or more associated intermittently to ephemerally ponded, small, shallow depressions.		x	x	
	Forested Peat Lands	Red maple-Tamarack Peat Swamp	A mixed swamp that occurs on organic soils (peat or muck) in poorly drained depressions.		x	x	
		Northern White Cedar Swamp	A conifer or mixed swamp that occurs on organic soils in cool, poorly drained depressions in central and northern New York, and along lakes and streams in the northern half of the state.		x	x	
Terrestrial	Open Uplands	Successional Old Field	A meadow dominated by forbs and grasses that occurs on sites that have been cleared and plowed and then abandoned.	x		x	watershed, available data did not distinguish the boundaries of this habitat type and therefore represent a data gap. It is likely mapped within the terrestrial cultural categories for cultivated land and pasture.
		Successional Shrubland	A shrubland that occurs on sites that have been cleared (for farming, logging, etc.) and then were abandoned. The vegetation community consists of at least 50% shrub cover.	x		x	available data do not distinguish the boundaries of this habitat type and therefore represent a data gap. It is likely mapped within the terrestrial cultural categories for cultivated land and pasture.
		Riverside Sand/Gravel Bar	A meadow community that occurs on sand and gravel bars deposited within, or adjacent to a river channel.		x	x	
		Shoreline Outcrop	A community that occurs along the shores of lakes and streams on rock outcrops. The shoreline is exposed to wave action and ice scour.		x	x	
		Calcareous Shoreline Outcrop	A community that occurs along the shores of lakes and streams on rock outcrops. The shoreline is exposed to wave action and ice scour.		x	x	

CLASSIFICATION	SUBCATEGORY	ECOLOGICAL COMMUNITY	DESCRIPTION	MAPPED YES	MAPPED NO	Data Gap1	COMMENTS
Terrestrial	Open Uplands	Cobble shore	A community that occurs on the well-drained cobble shores of lakes and streams. These shores are usually associated with high-energy waters, such as high-gradient streams.		x	x	
		Successional Fern Meadow	A meadow dominated by ferns that occurs on sites that have been cleared for logging, farming, etc.		x	x	This community is likely mapped within the terrestrial cultural categories for cultivated land and pasture, however, the boundaries of this habitat type represent a data gap.
		Successional Blueberry heath	A shrubland dominated by shrubs that occurs on disturbed sites with acidic soils.		x	x	
	Barrens and Woodla	Oak Openings	A grass-savanna community that occurs on well-drained soils.		x	x	In New York these originally occurred as openings within extensive oak-hickory forests.
	Forested uplands	Appalachian Oak-Hickory Forest	A hardwood forest that occurs on well-drained sites. Dominant trees include oaks, hickories, white ash, and red maple. This forest occurs predominantly in the Eastern Ontario Plains Region (Vandruff and Pike, 1992; Reschke, 1990).	x			
		Beech-Maple Mesic Forest	A hardwood forest that occurs on moist, well-drained, usually acid soils. Beech and sugar maple co-dominate in these forests. This forest occurs predominantly in the Appalachian Plateau (Vandruff and Pike, 1992; Reschke, 1990).	x			
		Successional Northern Hardwood	A hardwood or mixed forest that occurs on sites that have been previously cleared. Dominant tree species include aspens, balsam poplar, black cherry, red maple, white pine, paper birch, white or green ash, and American elm.	x			
		Successional Southern Hardwood	A hardwood or mixed forest that occurs on sites that have been previously cleared. Dominant tree species include gray birch, hawthorns, sassafras, box elder, American or slippery elm, red or silver maple, and eastern red cedar.	x			
		Appalachian Oak-Pine Forest	A mixed forest that occurs on sandy soils or on slopes with rocky soils that are well-drained. The canopy is dominated by a mixture of oak and pine.	x			See Section 2.3 for explanation for mapping Appalachian oak-pine forest, hemlock-northern hardwood forest, or pine-northern hardwood forest.
		Hemlock-Northern Hardwood Forest	A mixed forest that typically occurs on mid to lower slopes of ravines and on moist well-drained sites at the margins of swamps. Hemlock will co-dominate with deciduous species such as beech, sugar maple, or red maple.	x			
		Pine-Northern Hardwood Forest	A mixed forest that occurs in gravelly outwash plains or other sandy soils. The dominant trees are pines mixed with deciduous trees such as birch or aspen.	x			
	Terrestrial Cultural	Successional Red Cedar Woodland	A woodland community that commonly occurs on abandoned agricultural fields and pastures. In mature stands, the red cedar can be rather dense.	x			See Section 2.3 for explanation for mapping successional red cedar woodland, pine plantation, spruce/fir plantation, or conifer plantation as one habitat type.
		Pine Plantation	A stand of pines planted for the cultivation and harvest of timber products, or to provide wildlife habitat, soil erosion control, windbreaks, or landscaping. More than 50 to 90% of the canopy consists of pine.	x			
		Spruce/Fir Plantation	A stand of softwoods planted for the cultivation and harvest of timber products, or to provide wildlife habitat, soil erosion control, windbreaks, or landscaping. More than 50 to 90% of the canopy consists of spruce.	x			

CLASSIFICATION	SUBCATEGORY	ECOLOGICAL COMMUNITY	DESCRIPTION	MAPPED YES	MAPPED NO	Data Gap1	COMMENTS
Terrestrial	Terrestrial Cultural	Conifer Plantation	A stand of softwoods planted for the cultivation and harvest of timber products, or to provide wildlife habitat, soil erosion control, windbreaks, or landscaping. This category excludes stands where pines or spruces dominate.	x			
		Mowed Lawn with Trees	Residential land where groundcover is dominated by clipped grasses and forbs that have greater than 30% tree cover.	x			See Section 2.3 for explanation of mapping mowed lawn and mowed lawn with trees as one habitat group
		Mowed Lawn	Residential land where groundcover is dominated by clipped grasses and forbs and tree cover is less than 30%.	x			
		Urban Structure Exterior, Urban Vacant Lot, and Paved Roads	Commercial, industrial, and transportation areas where land is dominated by structures, vacant lots with sparse cover, or pavement.	x			
		Gravel Mines	Excavations in a gravel deposit from which gravel has been removed.	x			
		Cropland/Row Crops	An agricultural field planted in row crops such as corn, potatoes, and soybeans.	x			See Section 2.3 for explanation of mapping cropland/row crops, cropland/field crops and pastureland as one habitat type.
		Cropland/Field Crops	An agricultural field planted in field crops such as alfalfa, wheat, timothy, and oats. This community includes hayfields that are rotated to pasture.	x			
		Pasture Land	Agricultural land permanently maintained (or recently abandoned as a pasture for livestock).	x			
		Orchards	A stand of cultivated fruit trees.		x	x	
		Vineyard	A stand of cultivated vines.		x	x	Data incomplete
		Hardwood Plantation	A stand of commercial hardwood species planted for the cultivation and harvest of timber products.		x	x	
		Unpaved Road/path	A sparsely vegetated road or pathway of gravel, bare soil or bedrock outcrop.		x	x	
		Brushy Cleared Land	Land that has been clear-cut or cleared by brush hog.		x	x	
		Riprap/Artificial Lake Shore	A lake shore or pond shore that is covered with coarse stones, cobbles, concrete slabs, etc. placed for erosion control. This habitat type is known to occur along the Onondaga Lake shoreline, but the extent to which it occurs throughout the watershed represents a data gap.		x	x	

CLASSIFICATION	SUBCATEGORY	ECOLOGICAL COMMUNITY	DESCRIPTION	MAPPED YES	MAPPED NO	Data Gap1	COMMENTS
Terrestrial	Terrestrial Cultural	Dredge Spoil Lake Shore	A lake shore or pond shore that is composed of dredge spills. This habitat type is known to occur along the Onondaga Lake shoreline, but the extent to which it occurs throughout the watershed represents data gap.		x	x	
		Dredge Spoils	An upland site where dredge spoils have been recently deposited.		x	x	
		Landfill/Dump	A site that has been cleared or excavated, where garbage is disposed.		x	x	
		Junkyard	A site that has been cleared for disposal or storage of primary inorganic refuse.		x	x	

Notes
[1]Categories marked with an X indicate a data gap is present.

SECTION 3

TYPES OF HABITAT IMPAIRMENTS

This section identifies the types of habitat impairments within the Onondaga Lake watershed. Identification of impairment types facilitates the selection of alternative strategies for habitat restoration. Habitat impairments noted during the literature review (Parsons *et al.*, 2003a) were divided into four categories in conformity with the following habitat types: aquatic, wetland, floodplain, and terrestrial. General habitat impairment categories for each respective habitat type are listed in Table 3.1 and described below. Impairments for aquatic habitats are described for the major waterbody (tributary and/or lake) located within each subwatershed; whereas, impairments for the remaining habitat types (wetland, floodplain, and terrestrial) are described according to the type of general impairment.

3.1 AQUATIC

Types of aquatic habitat impairments were identified based on the review of existing information and focused on two biological parameters: fish and macroinvertebrates. The annual Onondaga Lake Ambient Monitoring Program (AMP) conducted by Onondaga County and the NYSDEC biological stream assessment (Bode *et al.*, 1989) were the primary sources used for identifying aquatic habitat impairments. An overview of these biological assessments is provided below.

A stream visual assessment (SVA) was conducted in 2000 and 2002 in Onondaga Creek (mainstem only), Harbor Brook, and Ley Creek (North Branch and mainstem only) as part of the AMP (EcoLogic, 2003). This assessment included a comprehensive field survey of stream conditions including streambank condition; hydrologic alteration; bank stability; nutrient enrichment; barriers to fish movement; instream fish cover; size, diversity, and abundance of pools; riffle embeddedness; and observed macroinvertebrates (NRCS, 1999). A score was given to each element based on observations. Scores ranged from 1, indicating a highly degraded condition, to 10, indicating that element was most similar to natural conditions. Scores from each element observed were added together and the sum divided by the number of elements that were rated. An overall rating was then given to each stream segment as follows:

- Poor – Overall rating < 6.0
- Fair – Overall rating 6.1 – 7.4
- Good – Overall rating 7.5 – 8.9
- Excellent - Overall rating > 9.0

A biological stream assessment of selected segments of Onondaga Lake tributaries was conducted by NYSDEC in 1989 (Bode *et al.*, 1989). The assessment was based on macroinvertebrate species observed within each tributary. The objective of the survey was to document existing water quality of each tributary as it relates to urban and industrial waste discharges and residues. An overall water quality impairment rating was given to each tributary based on species richness (total number of species), number of Ephemeroptera, Plecoptera, and Trichoptera species (EPT) in a 100 organism sample, biotic index, percent model affinity (measure of similarity to a non-impacted community based on seven major groups), and field assessment. The level of impact was assessed for each parameter and then combined for all four parameters to form a consensus determination. The consensus determination was based on the majority of parameters in cases where a uniform consensus was not attained. A four-tiered classification system was used to describe the water quality impairment:

- Severely-impacted- Species richness =10, EPT value 0-1 (EPT all rare or absent), biotic index 8.51 – 10.0, percent model affinity < 35. Water quality is often limiting to both fish survival and fish propagation.
- Moderately-impacted- Species richness 11-18, EPT value 2-5 (EP generally rare or absent, T restricted), biotic index 6.51-8.50, and percent model affinity 35-49. Water quality is generally not limiting to fish survival, but is limiting to fish propagation.
- Slightly-impacted- Species richness 19-26, EPT value 6-10, biotic index 4.51-6.50, and percent model affinity 50-64. Water quality generally is not limiting to fish survival, but fish propagation may be limited.
- Non-impacted- Species richness > 27 species in riffles, EPT value >10, Biotic index > 4.5, and percent model affinity >64.

General impairments of aquatic habitats within the watershed are summarized below and listed in Table 3.1.

Channel Modification: As the stream gradient decreases, channel meandering typically increases. Development within the stream valley can result in changes to the meandering pattern and flow. Stream channelization can result in increased flows throughout a stream segment and loss of aquatic habitat. Signs of channelization can include an unnaturally straight stream segment, high banks, and uniform-sized bed materials (e.g., all cobble when mix of cobble and gravel expected).

Sediment Transport: Alterations in sediment transport can result due to alteration of the stream channel and surrounding riparian areas. Increased sediment loading due to loss of riparian vegetation is often observed in newly developed areas. Agricultural activities can lead to an increase in sediment loading.

Contamination: Contaminated sediments are located throughout the Onondaga Lake Watershed, with many areas identified through federal and state programs. These areas typically have lower diversity of organisms and can lead to bioaccumulation of contaminants through the food web.

Bank Stability: Excessive bank erosion typically occurs when riparian zones are degraded (vegetation removed) or where the stream is unstable due to changes in hydrology, sediment load, or isolation from the floodplain. Some bank erosion is normal in a healthy stream. High and steep banks are more susceptible to bank erosion.

Substrate Degradation: Substrate degradation includes changes in the composition of the substrate and predominance by one substrate (e.g., gravel). Other substrate impairments include substrate embedding (primarily in riffle areas), where gravel and cobble substrate become surrounded by fine sediment. This reduces or eliminates the interstitial spaces, reducing available habitat for aquatic invertebrates and fish species. High stream velocities, high sediment loads, and frequent flooding of an area may also lead to unstable substrates.

Within Onondaga Lake, substrate degradation is apparent in the form of oncolites. Oncolites are calcium carbonate concretions that are lighter than typical shoreline substrates. This results in a reduced ability for macrophytes to grow in these areas and increases shoreline instability.

Anoxic Conditions: Anoxic conditions typically occur in the hypolimnion of Onondaga Lake during the summer months. During fall turnover, anoxic conditions can occur throughout the entire water column due to mixing of the anoxic hypolimnion. The primary cause for anoxic conditions in lakes is excessive production from phytoplankton and algae, due to the increased availability of limiting nutrients.

Lack of Complexity (Riffles/Runs/Pools): Many streams lose complexity due to urban, suburban, or agricultural activities. A loss of riffles, runs, or pools or a predominance of one type indicates an impaired condition.

Barriers to Migration: Fish movement within a stream is critical for species distribution. In streams where natural or man-made barriers to movement already exist, fish migration can be impaired. Areas upstream of barriers may provide critical spawning or nursery habitat for native species.

Limited Cover for Biota (instream and bank): Availability of physical habitat is critical for survival and propagation of fish species. A variety of habitat types, including large woody debris, deep pools, overhanging vegetation, boulders and cobble, undercut banks, and dense macrophyte beds, increase the species diversity within the stream. Limited availability of cover indicates a more impaired habitat.

Invasive Species (flora and fauna): As native flora and fauna are removed from an area, invasive species may invade an abandoned niche. Invasive species impair habitat for native flora and fauna and generally outcompete native species due to lack of a native predator or grazer.

General impairments within each subwatershed are described below and summarized in Table 3.2.

3.1.1 Nine Mile Creek

The Nine Mile Creek subwatershed encompasses 115 square miles, of which, 42 square miles consists of the Otisco Lake watershed. The Otisco Lake watershed is not included in the habitat assessment for the Nine Mile Creek subwatershed since a separate framework for watershed management has been developed for that lake (Onondaga County Environmental Health Council, 1998). Primary concerns in the Otisco Lake Watershed included agricultural impacts, aquatic vegetation control, and shoreline erosion. Several recommendations were made related to information exchange/coordination; intermunicipal communication; monitoring data, collection, and reporting; agricultural watershed protection; public education and community outreach; and public access (see Appendix A for copy of report).

The headwaters of Nine Mile Creek receive water from Otisco Lake, resulting in warm headwaters instead of the typical cold headwaters section. The mid-section of the creek receives groundwater inputs resulting in a cold-water stream, which supports a significant trout fishery. The lower reaches become deeper and warmer before emptying into Onondaga Lake. Areas along the length of Nine Mile Creek are impaired by channel modification due to road construction and maintenance. Channel modification may limit the riffle/run/pool complexes throughout this stretch, increase bank erosion, and result in embedded substrate (reducing percolation through the substrate). Several bridges are located across the stream in these areas, which may limit habitat diversity directly adjacent to the bridge. The lower section of Nine Mile Creek flows through an industrial area with historic discharges and bank alterations. Sediments along this section are contaminated and are being assessed as an active hazardous waste site, as indicated in the Onondaga Lake Remedial Investigation (RI) Report (TAMS, 2002).

Two stations in lower Nine Mile Creek were assessed by NYSDEC in 1989 and given a moderately impacted rating. Substrate in the area just upstream of the mouth was defined as primarily clay with areas of rubble and gravel; while further upstream near Amboy the substrate consisted of large rocks, rubble, and gravel (Bode *et al.*, 1989). From the mouth of Nine Mile Creek to approximately one mile upstream, the substrate is primarily dominated by calcium carbonate encrusted sediments (personal observation – MH Murphy).

3.1.2 Onondaga Creek

Onondaga Creek, the second largest subwatershed, encompasses 110 square miles within the Onondaga Lake watershed. The headwaters originate in the southern portion of the watershed and flow north through the City of Syracuse before emptying into Onondaga Lake. The headwaters are located within a rural area of mixed agricultural and forest cover. Results of the SVA indicate poor conditions in the two most upstream sections with generally fair/good conditions downstream through the Onondaga Nation. From the Onondaga Nation to the mouth, conditions were generally fair/poor. Poor conditions indicate impairments in several of the categories assessed, such as impaired or altered stream channel, unstable banks, nutrient enrichment, increased suspended solids, or limited instream cover. Fair and good conditions indicate fewer impairments or a reduced level of severity in impairments.

3.1.3 Ley Creek

The Ley Creek subwatershed encompasses 29.5 square miles and is located within the northeastern portion of the Onondaga Lake watershed. The majority of Ley Creek was classified as poor by the stream visual assessment indicating that several impairments, such as altered stream channel, unstable banks, limited instream cover, and increased suspended solids are likely. The upper reaches of Ley Creek (South Branch) extend into the highly developed areas along Erie Boulevard East and Route 690. Contaminated sediments are located within areas of the stream as well (O'Brien and Gere, 1993).

3.1.4 Harbor Brook

Harbor Brook, one of the smaller subwatersheds, encompasses 13.5 square miles. A stream visual assessment was conducted in 2002. The majority of Harbor Brook was classified as poor by the stream visual assessment indicating that several impairments, such as altered stream channel, unstable banks, limited instream cover, and increased suspended solids.

3.1.5 Onondaga Lake

The Onondaga Lake subwatershed, including direct drainage areas as well as several small tributaries including, Bloody Brook, Sawmill Creek, East Flume, and Tributary 5A, cover 18.7 square miles. Both Tributary 5A and the East Flume are industrial drainage areas and have habitat impairments (contaminated sediments, channel modification, bank erosion, barriers to migration) based on the historical industrial use (TAMS, 2002). Tributary 5A flows under Interstate 690 through a pipe, which empties into Onondaga Lake. Fish movement is likely limited between the lake and this small tributary. The East Flume and Tributary 5A are currently being assessed as part of active hazardous waste sites (TAMS, 2002).

Sawmill Creek is a small tributary that flows into Onondaga Lake from the northeast. Sawmill Creek was assessed as moderately impacted based on the composition of the macroinvertebrate community (Bode *et al.*, 1989). The substrate in the sampled riffle area was characterized as gravel and rubble (Bode *et al.*, 1989).

Bloody Brook is a small tributary that flows into Onondaga Lake from the northeast just south of the Village of Liverpool. Habitat impairments along this stream include contaminated sediments from industrial sites. This tributary is being assessed as an active hazardous waste site (RI/FS being conducted under Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] – no data available). During the Bode *et al.* (1989) assessment, Bloody Brook was defined as moderately impacted and the substrate was characterized as rubble thickly covered with algae.

Onondaga Lake is approximately four and a half miles long and one mile wide. Onondaga Lake sediments are being addressed as a Superfund site, under the CERCLA process (TAMS, 2002). Habitat impairments in the lake include contaminated sediments, anoxic hypoliminion during summer, limited aquatic vegetation, impaired substrate (i.e., oncolites), exotic species, and hypereutrophic conditions. Many fish species have been identified in the lake (34 adult species captured from 2000-2002), with 85% of those adults exhibiting some natural reproduction in the lake (Onondaga County, 2003). Habitat for spawning and juvenile fish species is limited throughout the lake (Onondaga County, 2001).

3.2 WETLAND

General impairments of wetland habitats within the watershed are listed in Table 3.1 and described below.

3.2.1 Few Ecological Associations

Limited habitat diversity and limited interspersion of habitat types reduces the wildlife and aquatic resource value of wetlands. Few ecological associations (or a lack of different wetland types) within close proximity reduces the ability of a wetland habitat to supply food, shelter, breeding/nesting, overwintering, and migratory resting areas for a variety of wetland dependent species. A lack of adjacent varied and undeveloped terrestrial communities further reduces a wetland's ability to support a variety of animal species (Redington, 1996).

3.2.2 Contamination

Untreated urban and agricultural stormwater runoff, industrial pollution, and domestic pollution (sewage) introduce sediment and pollutants into wetlands. Increased sediment loads can bury native plant communities and/or change the hydrology of the wetland. Pollutant loads can contaminate wetland waters and create contaminated substrates. Toxins contained in the contaminated waters and/or substrates can affect wildlife directly via direct contact or indirectly via the movement of toxins up the food chain.

3.2.3 Invasive Species

Invasive plant species compromise the ability of wetlands to support wildlife by diminishing the number and variety of native plant species in an area, thus reducing food sources, cover types, vertical stratification, and the number of ecological associations.

3.2.4 Reduction/Fragmentation of Wetlands

Urban development, agriculture, and logging have resulted in the reduction and fragmentation of wetlands within the watershed. Reduction of wetland area impairs the ability of wetlands to provide the thirteen functions and values identified by the USACE (USACE, 1995). Wetland fragmentation interrupts wildlife movement and dispersal within the watershed.

3.2.5 Hydrologic Alterations

Hydrologic alterations have occurred within the watershed. Past development practices have generally reduced tree cover and funneled stormwater more directly towards streams and rivers; thus decreasing the amount of time it takes for rainfall to enter rivers, streams, and their associated wetlands. This practice has both increased flood stage levels and decreased groundwater levels. Past agricultural practices have often used ditches and tiles to drain water from former wetlands to convert the land to agricultural uses. These hydrologic changes create changes in wetland habitat that affect the habitat community structure and the ability of wetlands to support native flora and fauna.

3.3 FLOODPLAIN

General impairments of floodplain habitats within the watershed are listed in Table 3.1 and described below.

3.3.1 Floodplain Laterally Restricted

Access of high water flows to a floodplain reduces and attenuates flood flows and is important to the maintenance of stream channel shape and function. Access of high water flows to a floodplain also helps to maintain the physical habitat of these floodplain areas for flora and fauna. During high flow periods, floodplains facilitate sediment deposition outside of the stream channel and dissipate flood flow energies, thus preventing sediment deposition within the lake or streambed and preventing bank erosion (USDA, 1998). In contrast, a laterally restricted floodplain disrupts these stream processes and reduces habitat for plants and animals.

3.3.2 Vegetative Cover Limited

Important elements for a healthy stream/lake ecosystem are well vegetated floodplains, adjacent streams and open waters. The quality of the riparian zone increases with the width and complexity of the woody vegetation. During flood events, a vegetated floodplain provides flood water storage, dissipates energy during flood events, and controls erosion. During non-flooding periods, a vegetated floodplain reduces the amount of pollutants that reach the stream via surface runoff, cools stream/lake shore waters, and provides habitat (USDA, 1998). Whereas, the lack of a well vegetated, woody floodplain adjacent to streams and open waters will reduce or prevent these functions.

3.3.3 Invasive Species

The proliferation of invasive species within a floodplain can compromise the ability of floodplains to support wildlife by diminishing the number and variety of native plant species in an area, thus reducing food sources, cover types, vertical stratification, and the number of ecological associations.

3.3.4 Floodplain Urbanized

In urbanized settings, floodplains are often highly manipulated and/or restricted to protect valuable structures, properties, or resources. Anthropogenic impairments can include dams, berms, channel straightening, channel deepening, stream culverting, and replacement of floodplain vegetation with structures or pavement. These practices compromise the ability of the floodplain to facilitate sediment deposition, dissipate flood flow energies, prevent bank erosion, and provide habitat for plants and animals.

3.3.5 Agricultural Impacts

In agricultural settings, floodplains are often highly manipulated and/or restricted to protect or increase the area of agricultural lands. Anthropogenic impairments can include dams, berms, channel straightening, channel deepening, or removal of vegetation. These practices compromise the ability of the floodplain to facilitate sediment deposition, dissipate flood flow energies, prevent bank erosion, and provide habitat for plants and animals.

3.3.6 Contamination

Untreated urban and agricultural stormwater runoff, industrial pollution, and domestic pollution (sewage) introduce sediment and pollutants into floodplains. Increased sediment loads can bury native plant communities and/or change the hydrology of the floodplain. Pollutant loads can contaminate floodplain substrates. Toxins contained in the contaminated substrates can affect wildlife directly via direct contact or indirectly via the movement of toxins up the food chain (bioaccumulation).

3.3.7 Hydrologic Alterations

Hydrologic alterations have occurred within the watershed. Past urban and agricultural development practices have generally reduced tree cover and funneled stormwater more directly towards streams and rivers; thus decreasing the amount of time it takes for rainfall to enter waterways. This practice has both increased flood stage levels and decreased groundwater levels. Dams, berms, and other restrictive structures constructed within the floodplain can also alter the hydrology of the area. These hydrologic modifications create changes in floodplain habitat that affect the habitat community structure and the ability of the floodplain to support native flora and fauna.

3.4 TERRESTRIAL

General impairments of terrestrial habitats within the watershed are listed in Table 3.1 and described below.

3.4.1 Limited Strata or Plant Species Diversity

Vertical structure in a plant community can increase its habitat value. Vertical structure is formed by the development of plant species in different growth forms. Because of these growth forms, layers or strata of vegetation are found vertically in a community. Strata commonly recognized are: ground (or herbaceous) layer, shrub layer, understory or sapling layer, and tree layer. A vine or liana layer may also occur. A diverse vertical structure increases the niche availability and wildlife habitat value. Related to structure diversity is species diversity. With increased plant species diversity, habitat value may increase. A plant community dominated by a monoculture of one stratum has limited structural and species diversity. Its resultant niche availability and wildlife habitat value is very low.

3.4.2 Few Ecological Associations

Increased habitat diversity can increase the value of an area to wildlife. Few or limited terrestrial cover types within close proximity reduce the ability of an area to supply food, shelter, breeding/nesting, overwintering, and migratory resting areas for a variety of species (Redington, 1996).

3.4.3 Invasive Species

Invasive plant species compromise the ability of terrestrial lands to support wildlife by diminishing the number and variety of native plant species in an area, thus reducing food sources, cover types, vertical stratification, and the number of ecological associations.

3.4.4 Urbanization/Industrialization

Urbanization/industrialization of terrestrial lands eliminates or reduces the presence of food bearing plants, vertical vegetative stratification, and the number of ecological associations. Urbanization/industrialization also contributes to habitat fragmentation and habitat contamination.

3.4.5 Fragmentation

Continuous areas of non-urbanized terrain allow wildlife to move freely within the landscape. The presence of urban development or major transportation routes interrupts wildlife movement/dispersal and impairs habitat quality.

3.4.6 Contamination

Past urbanization, industrialization, and agriculture practices have sometimes resulted in the contamination of terrestrial soils by untreated urban and agricultural stormwater runoff, industrial pollution, and domestic pollution (sewage/refuse). Toxins contained in the contaminated soils can affect wildlife directly via direct contact or indirectly via the movement of toxins up the food chain.

3.3.7 Hydrological Alterations

Hydrologic alterations have occurred within the watershed. Past urban and agricultural development practices have generally reduced tree cover and funneled stormwater more directly towards streams and rivers; thus decreasing the amount of time it takes for rainfall to enter rivers, streams and contributing to lower groundwater levels. These hydrologic changes can create changes in terrestrial habitat that affect the habitat community structure and the ability of terrestrial lands to support native flora and fauna.

TABLE 3.1

SUMMARY OF TYPES OF HABITAT IMPAIRMENTS

AQUATIC	WETLAND	FLOODPLAIN	TERRESTRIAL
• Channel modification	• Few ecological associations	• Floodplain laterally restricted	• Limited strata or species diversity
• Sediment transport	• Contamination	• Vegetative cover limited	• Few ecological associations
• Contamination	• Invasive species	• Invasive species	• Invasive species
• Bank stability	• Reduction/fragmentation of wetlands	• Floodplain urbanized	• Urbanization/ Industrialization
• Substrate degradation	• Hydrologic alterations	• Agricultural impacts	• Fragmentation
• Anoxic conditions		• Contamination	• Contamination
• Lack of complexity		• Hydrologic alterations	• Hydrologic alterations
• Barriers to migration			
• Limited cover for biota			
• Invasive species			

TABLE 3.2 GENERAL AQUATIC HABITAT IMPAIRMENT CATEGORIES

Subwatershed	Segment [1]	Habitat Impairment Categories									
		Channel Modification	Sediment Transport	Contaminated Sediments	Bank Stability	Substrate Degradation	Anoxic Conditions	Lack of Riffle/ Run/ Pool	Barriers to Migration	Limited Cover for Biota	Invasive Species
Nine Mile Creek	Upper (NM08-NM10)	•			•			•			•
	Middle (NM06-NM07)	•			•			•	•	•	•
	Lower (NM01-NM05)	•	•	•	•	•		•		•	•
Onondaga Creek	Upper (OC14-OC19)		•		•						•
	Middle (OC07-OC13)		•		•			•		•	•
	Lower (OC01-OC06)	•	•	•	•	•		•		•	•
Harbor Brook	Upper (HB02)				•			•	•		
	Lower (HB01)	•	•	•	•	•		•		•	
Ley Creek	Upper (LC03-LC05)			•	•			•			
	Lower (LC01-LC02)	•	•	•	•	•		•		•	
Onondaga Lake	Littoral Zone		•	•	•	•				•	•
	Profundal Zone			•			•			•	•
	Sawmill Creek									•	
	Bloody Brook			•		•				•	
	Tributary 5A	•		•		•			•		
	East Flume	•		•		•			•	•	

Notes:

1. Stream segments within each subwatershed, which are shown in parentheses, correspond to stream segments illustrated in Figure 2.3.

SECTION 4

RESTORATION STRATEGIES DEVELOPMENT

Restoration strategies and measures were developed to address the types of habitat impairments within the Onondaga Lake watershed. These restoration strategies and measures were developed to achieve the habitat restoration goals and objectives described in the *General Habitat Restoration Goals Report* (Parsons *et. al*, 2003b). Conceptual alternative strategies and measures for habitat restoration are listed in Table 4.1 and are described below.

4.1 AQUATIC STRATEGIES

There are numerous habitat restoration strategies available for instream, stream edge, and lakeshore habitats. Specific strategies were selected to address the habitat restoration goals and objectives and to mitigate the types of habitat impairments identified within the watershed (see Table 4.2a).

4.1.1 Pool Creation

This strategy will restore stream dynamics in areas where channel modification or hydrologic changes have occurred resulting in reduced pool formation. A variety of techniques can be used to enhance pool formation within the stream channel such as wing deflectors and boulder clusters. Costs associated with this strategy are low to moderate.

4.1.2 Restoration of Floodplain Connectivity

Periodic flooding along a stream corridor is essential to maintain lateral functioning within the stream. Many fish species spawn in floodplain habitats during spring high flows. The young move into the stream or lake environment as water levels drop during late spring and early summer. Periodic flooding also restores the physical habitat within the stream by scouring some areas and depositing sediments in lower energy areas and maintaining an array of ecotones throughout the riparian corridor. An active floodplain can be restored to streams and open water areas by removing limiting structures. Restrictions to the floodplain can include dams, berms, channel straightening, channel deepening, and stream culverting. Costs associated with this strategy are moderate to high.

4.1.3 Invasive Species Control

An impaired habitat typically results in a loss of native flora and fauna and provides an opportunity for invasive species introduction. There are various methods to control invasive species, including chemical treatment, barriers to migration, and introduction of a predator. Costs associated with this strategy are low to high.

4.1.4 Dam Removal

Many dams have been put in place in watersheds to control water flow, prevent flooding, retain water for irrigation, and for use as hydropower. Many dams may no longer be functioning for their intended purpose and therefore, could be removed. Removal of dams allows increased connectivity between upstream and downstream areas and increases the functioning of streams and their floodplains. Costs associated with this strategy are high.

4.1.5 Fish Passages

Fish movement within a stream is critical for species distribution. In streams where natural or man-made barriers to movement already exist, fish migration can be impaired. Areas upstream of barriers may provide critical spawning or nursery habitat for native species. Specific impacts of each barrier need to be analyzed prior to making decisions to alter them. Stream obstructions can provide barriers to undesirable species as well as regulating stream dynamics; consideration for these functions needs to be carefully evaluated prior to restoration. Costs associated with these structures are moderate to high.

4.1.6 Best Management Practices - Agriculture

Best Management Practices (BMPs) can be implemented to reduce pollutant loading sediments and nutrients from uncontrolled nonpoint source stormwater runoff to streams from surrounding agricultural lands. Increased sediment loads due to lack of buffer habitats along a stream can significantly increase sediment loading downstream. Reducing sediment loading maintains aquatic habitats, particularly within the cobble or gravel substrates. Examples of Agricultural BMPs include restricting access to livestock within the waterway, catch basins to collect runoff from agricultural buildings, and maintaining a riparian buffer between fields and waterways. Costs associated with this strategy can vary from moderate to high depending on the specific activity undertaken.

4.1.7 Best Management Practices – Urban

BMPs can be implemented to reduce pollutant loading from urban development and urban activities. The primary disturbance to the stream must be identified and evaluated for potential restoration strategies. Examples of urban BMPs include creation of detention basins, wet ponds, wetland creation, and vegetated swales. Costs generally range from moderate to high.

4.1.8 Hypolimnetic Oxygenation

To improve habitat for coldwater species, the deeper hypolimnion can be oxygenated during periods of anoxia. Suitable shoreline area is necessary as a staging area for onshore storage, valving, and the oxygen supply. A delivery system is required to transport the oxygen from the shore-based facility to the hypolimnion. This delivery system would consist of a network of pipes/hoses and associated diffusers. Hypolimnetic oxygenation may create additional habitat for coldwater fish species and, increase hypolimnetic oxygen levels during stratification and lake-wide oxygen levels during fall turnover. Hypolimnetic oxygenation may have an impact on other habitat characteristics including nutrient and contaminant (mercury) cycling. Costs associated with this strategy can be high relative to other restoration strategies proposed.

4.1.9 Remediation of Contaminated Sediments

Two common remedial strategies for contaminated sediments are dredging (removal) and capping (isolation). The removal of contaminated sediments and backfilling with clean fill can provide suitable conditions for the development of habitat types for native species. Capping can also be used to sequester the contaminated sediments and create different habitat types. Costs associated with these strategies are high.

4.2. AQUATIC MEASURES

Aquatic measures available to implement the aquatic strategies detailed in Section 4.1 are included in Table 4.2a and in the text below. The habitat restoration goals and objectives to which they apply are also included in this table.

4.2.1 Boulder Clusters

Boulder clusters consist of groups of boulders placed in the stream channel to provide instream cover, reduce velocity, and create scour holes. The use of boulder clusters can be applied to a variety of habitat types including pools, riffles, and runs. The greatest benefits are typically achieved in areas with average flows greater than two feet per second. In larger streams, multiple boulders should be placed in an area; single boulders can be used for small stream channels. Boulder clusters work best in wide, shallow streams dominated by larger substrates (e.g., gravel, cobble; FISRWG, 2001). Costs associated with this strategy are generally low.

4.2.2 Log/Brush/Rock Shelters

Shelters can be installed in the lower portion of streambanks to enhance fish habitat, prevent streambank erosion, and provide shade to moderate temperature impacts. These shelters are most effective in low gradient streams with natural bends or meanders with pool areas. These low-cost natural structures provide habitat for aquatic invertebrates fish, and other organisms. In streams where natural log-jams do not occur, log shelters may provide necessary habitat. Often, log shelters can be combined with bank stabilization activities (e.g., vegetative plantings) to enhance food web dynamics (FISRWG, 2001).

4.2.3 Lunker Structures

These structures are wooden pallets imbedded into the streambank at the bed level to provide covered areas for fish shelter and to prevent streambank erosion. These structures are appropriate on the outside bends of streams where water depths can be maintained at or above the top of the structure. Additional fish habitat can be created with these structures in areas lacking sufficient habitat (FISRWG, 2001). These structures are not designed for streams dominated by fine sediments (e.g., sand or silt) or streams with heavy bed load movement. Installation of these structures may require heavy excavating equipment with moderate to high costs.

4.2.4 Grade Control Structures

These structures consist of the placement of rock, wood, and earthen material across the channel to create an area that is resistant to erosion and bed scour; reducing the power of flow in the degradational area (FISRWG, 2001). These structures can be used to build the bed in incised areas, improve bank stability in incised areas, and create pool areas upstream of the structure providing increased habitat during low water periods (FISRWG, 2001). Costs for this alternative are moderate to high.

4.2.5 Tree Cover

This low-cost strategy consists of the placement of fallen trees along the streambank to provide overhead cover, aquatic organism substrate and habitat, deflect stream current, and reduce scouring (FISRWG, 2001). Tree cover works well in unstable stream habitats with fallen trees placed along the top of the bank. Frequent maintenance of these structures is necessary to maintain stability and to assess the potential for downstream debris jams.

4.2.6 Weirs or Sills

Weirs or sills can be placed across the stream channel (anchored to the streambed) to create pools, control bed erosion, or to collect and retain gravel. In areas where impairments have resulted in uniform channels, a weir or sill can be placed to provide more diverse habitat. Riffle areas will develop downstream of these structures as a result of modified channel flow. These structures should not be placed in streams with heavy bed load or pool areas upstream of the structure will rapidly fill with material. Depending on the need, weirs can be placed perpendicular or angular to flow direction. A perpendicular design will typically create backwater habitat, while an angular design will tend to distribute scour and depositional patterns downstream (FISRWG, 2001). Costs associated with this strategy are moderate and may involve heavy equipment during installation.

4.2.7 Wing Deflectors

Wing deflectors are structures typically made of rock or rock-filled log cribs that are placed perpendicular to shore, but do not extend across the entire width of stream. These structures reduce bank erosion (deflects flow away from bank) and create scour pools by channelizing and accelerating flow through an area (FISRWG, 2001). These are best designed far enough downstream of riffle areas, so as not to damage the riffle. The best placement is in depositional areas that may benefit from the scouring created with the deflector. Bed material scoured from the area becomes deposited downstream, creating a clean gravel bar and habitat for certain species. Areas lacking physical diversity, especially pool habitat, are suitable for wing deflectors. Placed in series on alternating banks within a channelized area, wing deflectors can create a meandering channel increasing habitat diversity (FISRWG, 2001). Costs associated with these structures are moderate.

4.2.8 Littoral Zone Planting

Littoral zone planting can be implemented to enhance spawning and nursery habitats along lake shores. Planting should be conducted in low energy areas or a barrier put in place to reduce the impacts of high energy wave action. Once the plants are in place and firmly rooted, they will naturally provide an area that reduces wave energy. Costs for this strategy are generally moderate.

4.2.9 Shoreline Plantings

Shoreline plantings can be implemented to reduce erosion and control sediment inputs to the lake and tributaries. These are relatively low cost alternatives that can provide a wide range of benefits to the aquatic and terrestrial communities. Streambanks can be stabilized by a combination of vegetation and structural elements (e.g., layers of logs, engineered slope retention systems) to reduce erosion and control sediment inputs from the surrounding landscape.

4.3 WETLAND STRATEGIES

Restoration strategies typically used to restore general types of impaired wetland habitat are included in Table 4.2b and in the text below. The habitat restoration goals and objectives to which they apply are also included in this table.

4.3.1 Supplemental Plantings

Supplemental plantings can be used to increase the diversity, density, vertical stratification, and the number of ecological associations within a wetland area. Supplemental plantings can generally be accomplished by hand. Therefore, this strategy does not require bringing heavy equipment into the wetland area, which could disturb the existing wetland. Supplemental planting represents a relatively low cost and publicly acceptable strategy.

4.3.2 Addition of Habitat Enhancing Elements

The addition of habitat enhancing elements (e.g., logs, brush piles, rocks, snags, birdhouses, and nesting boxes) can increase the structure of a wetland and the diversity of animal species supported within a wetland area. These elements can be brought in by hand; however, some elements, such as the introduction of large logs or rocks may require the use of heavy equipment. The addition of habitat enhancing elements represents a relatively low cost and publicly acceptable strategy.

Within wetlands, changes in elevation can shift a wetland community from one type of ecological community to another. Therefore, the creation of topographical changes within a wetland can be used to enhance the number of habitat niches available for different ecotones within a wetland. This technique can be particularly useful in monocultures areas of native (e.g., cattails) or invasive (e.g., *Phragmites*) plant species. Topographical changes will need to be combined with the supplemental planting strategy discussed above.

Topographical changes represent a relatively moderate cost and publicly acceptable strategy with high technical merit for remedying the lack of multiple ecotones within a wetland area. The creation of topographical changes within a wetland will generally require the use of heavy excavation equipment or the introduction of fill material within a wetland, which may disturb the existing wetland. Any such elevational changes must be carried out in accordance with Nationwide Permits 18, 19, and 27.

4.3.3 Remediation of Contaminated Substrates

Phytoremediation (biological) and substrate removal (physical) are two common remedial strategies for contaminated wetland sediments. Phytoremediation reduces sediment contamination via biological processes. Phytoremediation involves the introduction of plant species capable of removing and/or degrading target contaminants. During the growing season, plants remove and sequester the contaminants away from other active biological entities. In some situations, the plant material (containing the sequestered contaminants) is harvested and disposed of properly. Phytoremediation represents a low to moderate cost and publicly acceptable strategy.

Removal of contaminated sediment eliminates or reduces contamination by physical means. Excavation must be combined with the supplemental plantings discussed above. Physical removal of sediment represents a moderate to high cost.

4.3.4 Improvement or Installation of BMPs

New York State has developed BMPs for controlling stormwater runoff from adjacent urban areas, construction sites, and agricultural lands (Urban Soil Erosion and Sediment Control Committee, 1997). The improvement or installation of area BMPs can reduce the movement of sediment and accompanying contaminants into wetlands. In addition, appropriately designed stormwater BMPs, such as detention or retention ponds, can slow the rate of runoff from developed lands, allowing for increased groundwater recharge and reduced peak flood flows. Implementation or improvement of the BMPs must comply with the New York State erosion and sediment control guidelines, pertinent state and federal wetland permits, and the New York State Pollution Discharge Elimination System (SPDES) requirements. BMPs represent a low to high cost strategy.

4.3.5 Control of Invasive Plant Species

Two major invasive plant species that affect wetlands within the Onondaga Lake watershed are purple loosestrife (*Lythrum salicaria*) and common reed (*Phragmites australis*). A strategy for controlling the proliferation of purple loosestrife involves the release of loosestrife-specific leaf-feeding beetles (*Galerucella pusilla* and *Galerucella calmariensis*). The beetles eat the leaves of the purple loosestrife, thereby killing the plants. The release of the beetle has been approved by the U.S. Department of Agriculture. Successful trials have been carried out at Montezuma National Wildlife Refuge in Seneca Falls, New York (Friedlander, 1997). Beetle releases represent a low cost control strategy.

Phragmites is a much more difficult plant to control and there is no one, well established control strategy available. Because *Phragmites* is intolerant of deep shade, one strategy for controlling the proliferation of *Phragmites* involves planting trees and large shrubs adjacent to the stands. The canopy created by the developing trees and shrubs acts to shade out the *Phragmites*, which grows best in direct sunlight. Tree and shrub plantings for the control of *Phragmites* represent a low cost and publicly acceptable strategy.

Another strategy to control existing stands or the proliferation of this species involves increasing the water depth in these areas. *Phragmites* prefer shallow water or moist soil; it does not tolerate deep water. Increasing the depth of water within a *Phragmites* stand may require increasing the water supply to an area, constructing a water retention berm, or excavation. These strategies represent moderate to high costs. Public acceptance of this strategy may vary depending on the strategy used and the location.

4.3.6 Reduction of Habitat Fragmentation

Constructed wetlands can be used to remedy the reduction and fragmentation of wetland habitat within the watershed. Wetlands constructed in uplands adjacent to existing wetlands can be used to add wetland acreage in areas that have been impacted by previous filling activities. Likewise, wetlands can be constructed to re-connect wetlands that have become fragmented by past land development activities. Wetland construction along streams or other similar landform positions can increase flood storage and help to trap and retain nutrients found in flood waters. Wetland construction represents a moderate to high cost strategy. Public support may vary depending on the ownership and location of land to be converted to wetland.

Structures called Amphibian-Reptile Wall and Culverts can be constructed to facilitate the passage of amphibians and reptiles between wetlands fragmented by roadways. The wall and culvert arrangement diverts the animals to specific roadway underpasses (USDOT, 2000). This strategy is best employed during the design phase of new roadways or the reconstruction of existing roadways. It is not well suited to retrofitting existing roadways that are not currently undergoing reconstruction. This strategy represents a moderate to high cost strategy. Public acceptance may vary depending on the cost of the project.

4.4 FLOODPLAIN STRATEGIES

Restoration strategies typically used to restore general types of impaired floodplain habitat are included in Table 4.2c and in the text below. The habitat restoration goals and objectives to which they apply are also included in this table.

4.4.1 Supplemental Plantings

Supplemental plantings can be used to remedy floodplains impaired by the lack of woody vegetation. The supplemental plantings will also increase the diversity, density, vertical stratification, and the number of ecological associations within the area. In addition, the plantings can be directed at limiting the prevalence of invasive species. Plantings can be especially beneficial if developed as stream buffers. Restriction of land use practices (such as agricultural activities) along with the plantings in these buffers can be particularly effective.

Supplemental plantings can generally be accomplished by hand. Therefore, this strategy does not require bringing heavy equipment onto the floodplain, which could disturb the existing floodplain. Supplemental planting represents a relatively low cost and generally publicly acceptable strategy.

4.4.2 Removal of Dams and Other Structures that Restrict the Floodplain

An active floodplain can be restored to streams and open water areas by removing anthropogenic limiting structures. Anthropogenic restrictions to the lateral spread of the floodplain can include dams, berms, channel straightening, channel deepening, and stream culverting.

Floodplain limiting structures are typically set in place to protect valuable structures, properties, or resources. Therefore, this removal strategy may not be practical or publicly acceptable in all situations. However, the strategy can prove valuable in more rural areas where berms or dams were set in place, which are no longer in use. Removal of these limiting structures represents a moderate to high cost strategy.

4.4.3 Creation of Floodplain for Incised Streams

When stream channels have become severely incised, water can no longer spill over onto the floodplain during high flow periods. Further down-cutting can be prevented by constructing wetlands within the former floodplain with trench connections to the incised stream. This arrangement allows floodwaters to expand into the constructed wetlands, thus dissipating water energies, allowing for sediment deposition, groundwater recharge, and water treatment via exposure to the wetland plants and soils. Trench and wetlands construction represents a moderate to high cost and publicly acceptable strategy.

4.4.4 Addition of Habitat Enhancing Elements

Addition of habitat enhancing elements (e.g., logs, brush piles, rocks, birdhouses, and nesting boxes) can increase the number and diversity of animal species supported within the floodplain. Addition of many of these elements can be brought in by hand; however, some elements, such as the introduction of large logs or rocks may require the use of heavy equipment, which can disturb the existing floodplain. Disturbances would need to be remedied by supplemental plantings. Addition of these habitat enhancing elements represents a relatively low cost and publicly acceptable strategy.

Vernal pool creation can increase the number and diversity of animal species, particularly amphibians and reptiles, supported by the floodplain. Vernal pools constitute a unique and increasingly rare type of ecological niche that is inhabited by many species of plants and animals. Vernal pool uniqueness is due to their small size, temporary nature, and absence of fish predation. Owing to the fact that the pools are devoid of fish predation, the breeding strategies of a number of amphibian species have evolved to the point of total reliance on this ecological niche (i.e., obligate species) (Commonwealth of Massachusetts, 1988). Many other amphibian, reptile, insect, and plant species utilize these pools in a facultative manner. Some species utilize the ponds for breeding purposes and early life developmental stages; then return to surrounding woodlands to live out the adult stage (e.g., wood frogs and spotted salamanders), while other species (e.g., green frogs and painted turtles) require the return to nearby streams, ponds, and marshes to live out the adult stage (Behler, 1979).

Though vernal pools can be found in shallow wetlands and in terrestrial depressions, wetlands (e.g., emergent marshes) often lack the tree canopy necessary to provide good vernal pool habitat and ephemeral terrestrial pools are unregulated. In addition, studies have shown that amphibian populations decline when development takes places within 300 meters (284 feet) of a vernal pool (Windmiller, 1999), making creation of vernal pools in terrestrial areas unproductive due to building pressures. Because development within floodplains is restricted under the Federal Emergency Management Agency (FEMA) regulations and because floodplains function optimally with a treed canopy (USDA, 1998), depressions can be constructed on the floodplain and lined with soils with high clay content such that the depressions will catch and hold water during the spring season and will provide increased vernal pool habitat within the area. Vernal pool creation should be accompanied by supplemental planting of the floodplain with tree species to provide appropriate canopy cover.

Excavation of the depressions may require limited use of heavy equipment, which can disturb the existing floodplain. Disturbances can be remedied by the supplemental plantings. Addition of vernal pools represents a relatively low cost and publicly acceptable strategy.

4.4.5 Remediation of Contaminated Soils

Phytoremediation (biological) and soil removal (physical) are two common remedial strategies for addressing contaminated soils. Phytoremediation reduces soil contamination via biological processes. Phytoremediation involves the introduction of plant species capable of removing and/or degrading target contaminants. During the growing season, plants remove and sequester the contaminants away from other active biological entities. In some situations, the plant material (containing the sequestered contaminants) is harvested and disposed of properly. Phytoremediation represents a low to moderate cost and publicly acceptable strategy.

Removal of contaminated soils eliminates or reduces contamination by physical means. Excavation must be combined with the supplemental plantings discussed above. Physical removal of contaminated soils represents a moderate to high cost strategy.

4.4.6 Improvement or Installation of BMPs

New York State has developed BMPs for controlling stormwater runoff from adjacent urban areas, construction sites, and agricultural lands (Urban Soil Erosion and Sediment Control Committee, 1997). The improvement or installation of area BMPs can reduce the movement of sediment and accompanying contaminants onto floodplains. In addition, appropriately designed stormwater BMPs, such as detention or retention ponds, can slow the rate of runoff from developed lands, allowing for increased groundwater recharge and reduced peak flood flows. Implementation or improvement of the BMPs must comply with the New York State erosion and sediment control guidelines, pertinent state and federal wetland permits, and SPDES requirements. BMPs represent a low to high cost strategy.

4.5 TERRESTRIAL STRATEGIES

Restoration strategies typically used to restore general types of impaired terrestrial habitat are included in Table 4.2d and in the text below. The habitat restoration goals and objectives to which they apply are also included in this table.

4.5.1 Supplemental Plantings

Supplemental plantings can be used to increase species diversity, density, vertical stratification, and the number of ecological associations within a terrestrial area. Plantings can be directed at limiting the prevalence or spread of invasive species.

Supplemental plantings can generally be accomplished by hand. Therefore, this strategy does not require bringing heavy equipment into the area, which could disturb the existing terrestrial community. Supplemental planting represents a relatively low cost strategy. Though supplemental planting is generally publicly acceptable, acceptance may vary depending on the ownership and location of target properties.

4.5.2 Establishment of Vegetated Buffer Zones

Well vegetated lands surrounding streams play an important role in watershed protection. Vegetative buffers next to streams and open waters provide nutrient and pollutant removal from surface runoff and sub-surface flows; sediment trapping; groundwater recharge; moderation of storm flows to streams; flood storage; soil stabilization; shading (temperature moderation) for water bodies; a source of detritus for aquatic organisms; and creates habitat.

In addition, the establishment of vegetated buffer zones adjacent to wetlands, tributaries, and open water areas permits the travel and dispersal of wildlife along riparian corridors, allows wildlife access to water sources, and provides wildlife with cover when in close proximity to urbanized areas. To improve habitat quality and decrease fragmentation of the wildlife corridor, this strategy may need to be combined with the supplemental plantings.

The creation of vegetated buffer zones represents a variable cost strategy. It could range from voluntary cooperation by individual landowner to expensive land purchases. Public acceptance will likely vary depending on the ownership, location, and cost of the various buffer zones. The establishment of vegetated buffer zones has high technical merit; however, in developed areas, the ability to create a continuous buffer zone along riparian corridors may be limited or impractical. Permission must be obtained from all property owners along the proposed corridor.

4.5.3 Addition of Habitat Enhancing Elements

The addition of habitat enhancing elements (e.g., logs, brush piles, rocks, birdhouses, and nesting boxes) can increase the number and diversity of animal species supported by a terrestrial habitat. Addition of many of these elements can be brought in by hand; however, some elements, such as the introduction of large logs or rocks may require the use of heavy equipment, which can disturb the existing terrestrial community. Disturbances will need to be remedied by supplemental plantings. Permission from the landowner must be obtained for any such addition of habitat enhancing elements. Addition of habitat enhancing elements represents a relatively low cost and generally publicly acceptable strategy.

4.5.4 Reduction of Habitat Fragmentation

Cleared areas can be re-planted where practical to connect disrupted forested areas and thus improve habitat connectivity (reduce terrestrial habitat fragmentation). This strategy can target the replication of adjacent forested areas or the development of a different species mix (such as evergreens for winter cover) if such a mix would benefit the overall habitat value. This strategy can increase the number of ecological associations in the area and create edge effects while decreasing habitat fragmentation.

The re-planting of cleared areas represents a variable cost strategy. It could range from voluntary cooperation by individual landowner to expensive land purchases. Public acceptance will likely vary depending on the ownership, location, and cost of the re-planting effort. Decreasing habitat fragmentation has high technical merit; however, in developed areas, the ability to re-plant cleared areas may be limited or impractical. Permission will need to be obtained from all property owners of the target locations.

Salamander tunnels and passages for large mammals can be constructed to facilitate the passage of salamanders and mammals between terrestrial habitats fragmented by roadways. Salamander tunnel design will vary depending on the biology of the target species. Passages for large mammals in central New York are most likely to be underpasses, and may consist of arched or box culverts. Locating the passages near the animals' natural travel corridor is crucial to their success. For salamanders, this means connecting terrestrial habit to vernal pool areas where they mate and lay their eggs. For carnivores, this means placing the structures close to stream corridors or drainage areas. For ungulates, it involves doing the opposite, that is placing the structures far from carnivores (their predators) and providing a clear view of the structures' entrance (USDOT, 2000).

This strategy is best employed during the design phase of new roadways or the reconstruction of existing roadways. It is not well suited to retrofitting existing roadways that are not currently undergoing reconstruction. Construction of these passages must comply with all state and federal highway regulations and potentially state and federal wetland regulations when the passages are constructed in near stream corridors or in drainage areas. Construction of the salamander tunnels and large mammal passages represents a moderate to high cost strategy. Public acceptance may vary depending on the cost of the project.

4.5.5 Remediation of Contaminated Soils

Phytoremediation (biological) and soil removal (physical) are two common remedial strategies for addressing contaminated soils. Phytoremediation reduces soil contamination via biological processes. Phytoremediation involves the introduction of plant species capable of removing and/or degrading target contaminants. During the growing season, plants remove and sequester the contaminants away from other active biological entities. In some situations, the plant material (containing the sequestered contaminants) is harvested and disposed of properly. Phytoremediation represents a low to moderate cost and publicly acceptable strategy.

Removal of contaminated soils eliminates or reduces contamination by physical means. Excavation must be combined with the supplemental plantings discussed above. Physical removal of contaminated soils represents a moderate to high cost strategy.

4.5.6 Improvement or Installation of BMPs

New York State has developed BMPs for controlling stormwater runoff from adjacent urban areas, construction sites, and agricultural lands (Urban Soil Erosion and Sediment Control Committee, 1997). Appropriately designed stormwater BMPs, such as detention or retention ponds, can slow the rate of runoff from developed lands, allowing for increased groundwater recharge and reduced peak flood flows. Implementation or improvement of the BMPs must comply with the New York State erosion and sediment control guidelines, pertinent state and federal wetland permits, and SPDES requirements. BMPs represent a low to high cost strategy.

4.6 WATERSHED-WIDE PROTECTION MEASURES

In addition to the technical strategies discussed above, there are many educational, planning, and political strategies that can be utilized to accomplish habitat restoration and protection within the watershed. These non-technical strategies are adopted from Raymond (1996) and the

Association of State Wetland Managers (undated) and are briefly summarized in Table 4.1 and in the text below.

4.6.1 Initiation of Education/Informational Programs

Educational and informational programs can be initiated to facilitate watershed habitat protection. These types of programs help to inform the public of the need for conservation measures and encourage voluntary adoption of protection techniques (e.g., conservation easements) and individual land stewardship.

4.6.2 Development of Incentives

The development of incentives for the adoption of conservation measures (e.g., cost sharing or the transfer of development rights) encourages private land owners to implement watershed protection measures.

4.6.3 Purchase of Critical Lands

For critical habitat areas within the watershed, land purchase may represent the best protection or management strategy. Stream corridor establishment, protection, and restoration can greatly benefit from land purchases.

4.6.4 Creation of New Regulations

The proposition of new regulations (e.g., zoning, land use, or water use laws) provides the authority to compel compliance with required protection strategies.

4.6.5 Improvement of Agency Coordination

Many impediments to watershed management are institutional rather than scientific. Wetland, stormwater, floodplain management, water supply, pollution control, and other programs have typically been authorized by separate enabling legislation. Programs have separate budgets, are often located at separate locations, have different client groups, and separate bureaucracies. These barriers can be overcome by bringing people and programs with common interests together.

4.6.6 Development of a Watershed Management Plan

The development of watershed management plan is one method for managing natural resources and addressing environmental issues at the watershed level. Typical management plans consider water quality protection, floodplain management, stormwater management, water supply maintenance, protection and restoration of wetlands, protection and restoration of wildlife habitat, and protection and restoration of aquatic ecosystems.

TABLE 4.1

SUMMARY OF ALTERNATIVE STRATEGIES FOR HABITAT RESTORATION

AQUATIC	WETLAND	FLOODPLAIN	TERRESTRIAL	WATERSHED WIDE
STRATEGIES: • Pool creation • Restoration of floodplain connectivity • Invasive species control • Dam removal • Fish passages • BMP-agriculture • BMP-urban • Hypolimnetic oxygenation • Remediation of contaminated sediments MEASURES: • Boulder clusters • Log/brush/bock shelters • Lunker structures • Grade control structures • Tree cover • Weirs or sills • Wing deflectors • Littoral zone planting • Shoreline plantings	• Supplemental plantings • Addition of habitat enhancing elements • Remediation of contaminated substrates • Improvement or installation of BMPs • Invasive plant species control • Reduction of habitat fragmentation	• Supplemental plantings • Removal of dams and other structures that restrict floodplain • Creation of floodplain for incised streams • Addition of habitat enhancing elements • Remediation of contaminated soils • Improvement or installation of BMPs	• Supplemental plantings • Establishment of vegetated buffer zones • Addition of habitat enhancing elements • Reduction of habitat fragmentation • Remediation of contaminated soils • Improvement or installation of BMPs	• Initiation of educational/ informational programs • Development of incentives • Purchase of critical lands • Creation of new regulations • Improvement of agencycoordination • Development of a watershed management plan

TABLE 4.2a ASSESSMENT FOR ALTERNATIVE STRATEGIES FOR AQUATIC HABITAT RESTORATION

Strategy /Measure	Goals/ Objective Satisfied [1]	Relative Cost	Impairment Addressed									
			Channel Modification	Sediment Transport	Contamination	Bank Stability	Substrate Degradation	Anoxic Conditions	Lack of Complexity	Barriers to Migration	Limited Cover for Biota	Invasive Species
Strategies												
Pool Creation	2/A; 3/B	Low/Moderate	•						•		•	
Restoration of floodplain connectivity	2/A; 3/A; 3/B	Moderate/High	•	•		•			•		•	
Invasive Species Control	2/C	Low/High										•
Dam removal	2/A; 3/B	High	•	•					•	•		
Fish passages	2/A	Moderate/High								•		
BMPs Agriculture	2/A; 2/B; 5/C	Moderate/High		•								
BMPs Urban	2/A; 2/B; 5/C	Moderate/High		•	•							
Hypolimnetic oxygenation	5/A; 5/D	High						•				
Remediation of Contaminated Sediments	5/A; 5/C	High			•		•					
Measures												
Boulder clusters	2/A; 3/B	Low	•	•					•		•	
Log/Brush/Rock shelters	2/A; 3/A; 3/B	Low				•			•		•	
Lunker structures	2/A; 3/A	Moderate/High				•			•		•	
Grade control structures	2/A; 3/A; 3/B	Moderate/High				•			•			
Tree cover	2/A; 3/A; 3/B	Low									•	
Weirs/sills	2/A; 3/B	Moderate		•		•			•			
Wing deflectors	3/A; 3/B	Moderate	•	•		•			•			
Littoral zone planting	5/A; 5/B; 5D	Moderate					•				•	
Shoreline plantings	2/A; 3/A; 5/A	Low	•		•	•	•				•	

Notes:

[1] See notes at end of Table 4.2d.

TABLE 4.2b ASSESMENT OF ALTERNATIVE STRATEGIES FOR WETLAND HABITAT RESTORATION

Strategy	Goals/Objective Satisfied (1)	Relative Cost	Impairment Addressed				
			Few Ecological Associations	Contamination	Invasive Species	Reduced or Fragmented Wetlands	Hydrologic Alterations
Supplemental plantings	1/A,B,F,G, H; 4/A,B,D,E,G	Low	•		•	•	
Addition of habitat enhancing elements	1/A,F,H; 4/A,G	Low	•				
Remediation of contaminated substrates	1/A,B,H; 4/A,E,G	Low/High		•			
Improvement or installation of BMPs	1/A,B,F,H; 4/A,B,E,G	Low/High		•			•
Invasive plant species control	1/A,,G,H; 4/A,E,F	Low/High			•		
Reduction of habitat fragmentation	1/A,B,E,F,H; 4/A,B,D,E,G	Moderate/High	•			•	

Notes:
[1] See notes at end of Table 4.2d.

TABLE 4.2c ASSESSMENT OF ALTERNATIVE STRATEGIES FOR FLOODPLAIN HABITAT RESTORATION

Strategy	Goals/Objective Satisfied (1)	Relative Cost	Impairment Addressed						
			Floodplain Laterally Restricted	Vegetative Cover Limited	Invasive Species	Floodplain Urbanized	Agricultural Impacts	Contamination	Hydrologic Alterations
Supplemental plantings	1/A,B,E,F,G,H; 4/A,B,D,E,F,G	Low		•	•	•	•		•
Removal of dams and other structures that restrict the floodplain	1/A,B,C; 4/A,B,C	Moderate/High	•			•	•		•
Creation of floodplain for incised streams	1/A,B,C; 4/A,E,G	Moderate/High	•			•	•		•
Addition of habitat enhancing elements	1/A,C,D,H; 4/A,C,G	Low							
Remedation of contaminated soils	1/A,B,C,D,F; 4/A,B,C,E	Moderate/High		•		•		•	
Improvement or installation of BMPs	1/A,B,C,H; 4/A,B,C,G	Low/High				•	•	•	•

Notes:
[1] See notes at end of Table 4.2d.

TABLE 4.2d ASSESSMENT OF ALTERNATIVE STRATEGIES FOR TERRESTRIAL HABITAT RESTORATION

Strategy	Goals/Objective Satisfied [(1)]	Relative Cost	Impairment Addressed						
			Limited Strata or Species Diversity	Few Ecological Associations	Invasive Species	Urbanization/ Industrialization	Fragmentation	Contamination	Hydrologic Alterations
Supplemental plantings	1/B,C,D,E,F,G,H; 4/B,C,D,E,F,G	Low	•	•	•	•	•		•
Establishment of vegetated buffer zones	1/A,B,C,D,E,F,G,H ; 4/A,B,C,D,E,F,G	Low/High	•	•	•	•	•		•
Addition of habitat enhancing elements	1/C,D,H; 4/C,G	Low		•		•			
Reduction of habitat fragmentation	1/A,B,C,D,E,F,G,H ; 4/A,C,G	Moderate/High	•	•	•	•	•		•
Remedation of contaminated soils	1/C,D,F,H; 4/C,E,G	Moderate/High	•			•		•	
Improvement or installation of BMPs	1/A,B,C,H; 4/A,B,C,G	Low/High				•		•	•

Notes:
[1] See notes on next page.

Notes: These notes are applicable to Tables 4.2a through 4.2d.

Goal 1: Restore and protect wetlands, floodplains, and terrestrial habitat.

Objective A. Improve the functionality of impaired wetlands such that the number of Corps recognized functions and values supported by the wetlands are increased.

Objective B. Restore floodplain hydrology and vegetative cover along adjacent tributaries where practical.

Objective C. Improve the functionality of terrestrial habitat cover along riparian corridors such that the number of Corps recognized functions and values supported by the terrestrial cover are increased.

Objective D. Improve upland habitat structure and composition where practical.

Objective E. Improve connectivity between fragmented habitats.

Objective F. Restore native plant communities in disturbed wetland, floodplain, and terrestrial habitats.

Objective G. Reduce the overabundance and proliferation of invasive plant species.

Objective I. Encourage public support for implementation of protective measures along stream corridors on public and private lands.

Objective H. Protect the habitat of threatened and endangered species and improve/expand the habitat where practical.

Goal 2: Restore and protect instream aquatic habitat.

Objective A. Improve the habitat for aquatic and semi-aquatic species.

Objective B. Improve water quality to support native plant and animal communities.

Objective C. Reduce the introduction and proliferation of exotic plant and animal species.

Goal 3: Restore and protect stream hydrology and channel processes.

Objective A. Restore and stabilize areas of human induced bank instability.

Objective B. Restore natural flow regime

Goal 4: Restore and protect wetlands, floodplains, and terrestrial habitat surrounding Onondaga Lake.

Objective A. Improve the functionality of impaired wetlands along the lake shore such that the number of Corps recognized functions and values supported by the wetlands are increased.

Objective B. Restore floodplain hydrology and vegetative cover along the lake shore where practical.

Objective C. Improve the functionality of terrestrial habitat cover along the lake shore such that the number of Corps recognized functions and values of supported by terrestrial cover are increased.

Objective D. Improve the connectivity between fragmented habitats along the lake shore.

Objective E. Restore native plant communities in disturbed wetland, floodplain, and terrestrial habitats.

Objective F. Reduce the overabundance and proliferation of invasive plant species.

Objective G. Protect the habitat of threatened and endangered species and improve/expand the habitat where practical.

Objective H. Encourage the public support for implementation of protective measures along public and private lands surrounding the lake.

Goal 5: Restore and protect aquatic habitat within Onondaga Lake.

Objective A. Improve the habitat for aquatic and semi-aquatic species.

Objective B. Improve native aquatic flora.

Objective C. Improve water quality to support native plant and animal communities.

Objective D. Reduce introduction and proliferation of exotic plant and animal species.

SECTION 5

RESTORATION STRATEGIES EVALUATION

5.1 RESTORATION STRATEGIES EVALUATION

The next project task will involve preparation of the SCHRP. The SCHRP will identify general locations of impaired habitats and evaluate the alternative strategies developed in this report to address such impairments, thus improve aquatic, wetland, floodplain, and terrestrial habitats within the watershed. The evaluation will consider multiple aspects, such as, hazardous chemical sites, recreation trails, parks neighborhood/community concerns and issues, community acceptance, ease of restoration, land ownership (i.e., public or private), land cover (i.e., developed or vegetated), land use, ecological sustainability, and the obtainability of federal/state/ local permits. Additionally, the SCHRP will identify the opportunities, limitations, and potential funding sources available for implementing such habitat restoration strategies. The SCHRP will provide a framework for establishing and prioritizing short- and long-term plans for habitat restoration within the watersheds.

SECTION 6

SUMMARY

This report identifies habitat types within the Onondaga Lake watershed and general types of habitat impairments within the watershed. Alternative conceptual strategies were developed to address those impairments in order to improve aquatic, wetland, floodplain, and terrestrial habitats within the watershed. In addition, this report provides a summary of the path forward for evaluating alternative strategies and developing the SCHRP.

SECTION 7

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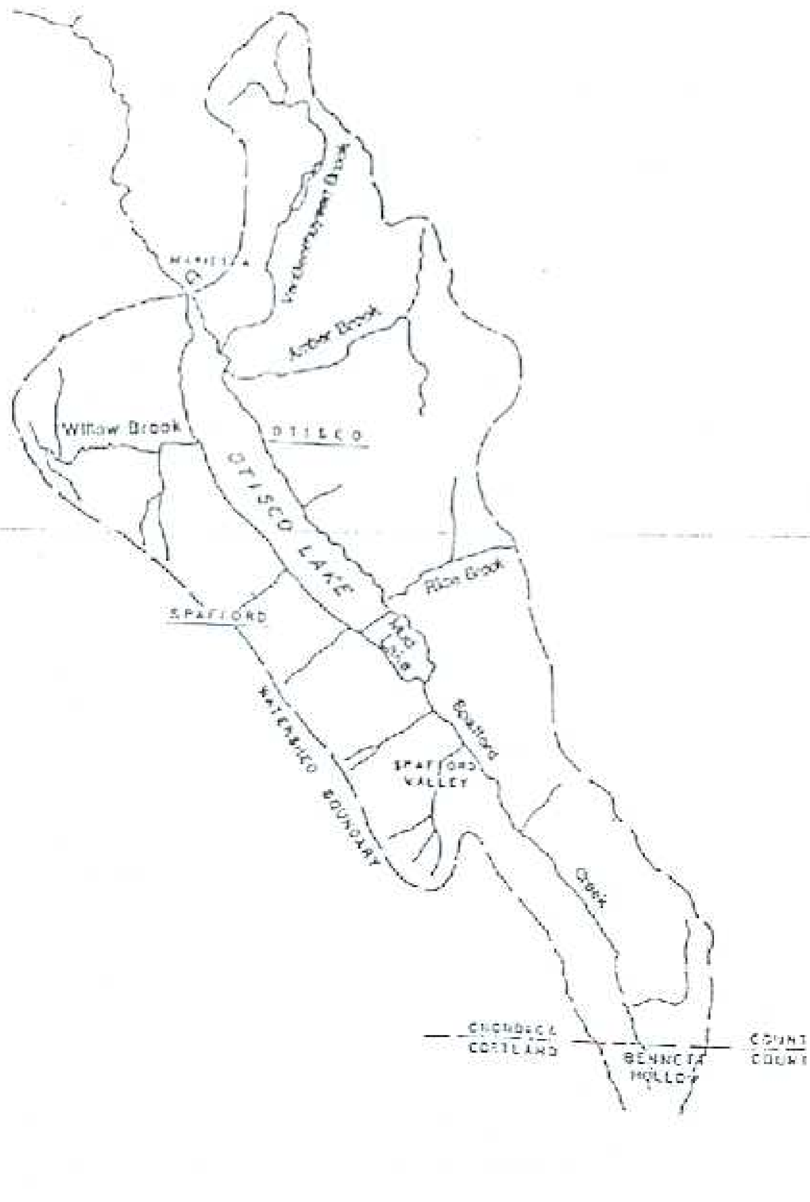
APPENDIX A

REPORT COPY

"ONONDAGA COUNTY ENVIRONMENTAL HEALTH COUNCIL, 1998"

A Framework for Otisco Lake Management



Onondaga County
County Water Quality Coordinating Committee Tier 3 Grant

INTRODUCTION

Otisco Lake is an important source of drinking water for Onondaga County residents. In the early 1980s, water supply and lake quality concerns arose over high turbidity levels. This resulted in a number of diagnostic investigations being initiated and the implementation of several remediation measures. Despite a paucity of limnological data prior to 1980 and no scientific evidence to support such an assertion, general public perception at the time was that the lake's water quality had degraded.

Between 1981 and 1983, the United States Geological Survey (USGS) conducted baseline monitoring investigations to provide an initial understanding of watershed (tributary) inputs to Otisco Lake. During this same time period, the United States Soil Conservation Service (SCS) initiated a Watershed Protection Feasibility Study to determine how upland agricultural sources of nutrient and sediment inputs to Otisco Lake tributaries be curtailed.

In 1985, the Onondaga County Environmental Management Council (EMC) completed the Otisco Lake Water Quality Management Plan, which recommended that a number of management and pollution preventive initiatives be undertaken. However, the relative contribution of pollutant sources and what role, if any, in-lake processes had upon the lake's current water quality condition were not well understood. Thus, the Plan recommended that several special lake investigations be undertaken to resolve these issues before potentially costly and perhaps ineffective remediation efforts were taken.

FRAMEWORK'S OBJECTIVE

Being a primary source of drinking water and a valued recreational resource for Onondaga County, Otisco Lake has been given highest priority status in the Onondaga County Water Quality Strategy. Nearly fifteen years after the inception of the original Otisco Lake Water Quality Management Plan, an update is needed. Thus, this framework is intended to provide guidance for protecting Otisco Lake during the ensuing decade. At the same time, it is worth noting that the original Plan was primarily intended to serve as a diagnostic blueprint for short-term corrective actions. This in effect has been done as a large majority of the Plan's recommendations were implemented.

LAKE AND WATERSHED DESCRIPTION

Otisco Lake is located in southwestern Onondaga County and is the easternmost of New York State's Finger Lakes. It has a surface area of about 3.4 square miles, a length of approximately 5.4 miles, and an average width of .5 miles. A causeway crosses the lake about one mile north of the mouth of Spafford Creek and effectively creates a northern and southern basin. North of the causeway, Otisco Lake has an average depth of 33 feet with a maximum depth of almost 60 feet. The southern basin or "Mud Lake" averages three feet with a maximum depth of only 9 feet.

LAKE AND WATERSHED DESCRIPTION (Cont.)

There is also a constriction near the lake's northern terminus known as the "Narrows." Just north of this area, Otisco Lake empties through the outlet spillway into Nine Mile Creek. The major tributaries entering Otisco Lake include: Spafford Creek, entering at the lake's southern extreme, with Amber Brook, Van Benthuysen Brook and Rice's Brook entering the east side, and Willow Brook entering on the west.

The Otisco Lake watershed contains nearly 24,000 acres (23,844 acres) with all but a very small portion being entirely within Onondaga County. It comprises the southern extreme of the Nine Mile Creek drainage as well as being part of the Onondaga Lake watershed. The watershed is predominantly within the towns of Otisco and Spafford with smaller portions contained within the Onondaga County towns of Marcellus (north), Onondaga (northeast), Tully (southeast), and in the Cortland County town of Preble (south). Over 50% of the watershed is in active agricultural use with another 45% forested. The watershed population is an estimated 3,300 permanent and temporary residents combined.

WATER RESOURCE USES

Otisco Lake is a multiple use resource that serves as a drinking water supply source for the Onondaga County Water Authority (OCWA) as its primary use. OCWA withdraws up to an average of 20 million gallons daily (mgd) from Otisco Lake for supply to Onondaga County residents, primarily in the western and central portion of the OCWA service area. In recent years, average withdrawals have been closer to 17 mgd.

Public access is available from a New York State Department of Conservation (NYSDEC) access point located where the causeway joins the lake's west side. There is a marina and boat ramp available along the eastern shore of the lake; just north of the causeway. With the exception of the causeway, shoreline access is essentially limited to the extreme northeastern corner of the lake near the lake spillway. The majority of recreational usage is through lakeshore residents.

Onondaga County has an option on acceptance of bequeath land (Hirsch property) along the northeastern shore of Otisco Lake. At present, it has not been determined whether the County will accept the property, or what specific public use the land would be utilized for, if ownership is assumed by the County.

The eastern side of the lake is more populated than the western shore. Most of the western shore is steeply sloped with the exception of the northwestern and southwestern corners of the lake. The Otisco Lake Community Association has an active summer season program that includes water-based recreational activities primarily for children. While supporting a cold water (trout) recreational fishery, Otisco Lake also supports a walleye fishery and in recent years, has achieved a level of notoriety for its norlunge catches.

WATER QUALITY CONDITIONS

Water Quality-1980s

Intensive monitoring throughout most of the decade showed no evidence that Otisco Lake's water quality had declined. Through monitoring and a series of special studies, Upstate Freshwater Institute (1989) described Otisco Lake as mesotrophic with the main source of turbidity in south Otisco Lake (south of the causeway) attributed to wind-driven resuspension. The lower waters of the main basin (below about 12 meters) become close to or anoxic when summer stratification is established. The shape of the lake basin is thought largely responsible for this occurrence with annual differences in anoxia likely due to normal climatic variability.

While internal (bottom) sources of phosphorus are thought to contributing to algal bloom occurrences, the amount of internally available phosphorus has never been accurately quantified. Whether due to climatic variation or decreases in nutrient loading, or from zooplankton grazing, a decreasing trend in phytoplankton biomass was shown for the 1979 to1988 time period. The presence of the natural occurring calcium carbonate precipitation phenomena known as "whiting" was found to contribute to lake turbidity levels.

Water Quality - 1990s

In the 1990s, less intensive limnological monitoring has been done, but OCWA conducts a rigorous on-lake-monitoring component as part of its overall water supply monitoring program. Lake data collection includes phytoplankton enumeration as well as temperature and dissolved oxygen profiling.

Between 1991 and 1994, the Onondaga County Health Department conducted selected tributary monitoring of several tributaries of the eastern watershed including Amber Creek, Van Benthuysen Brook and Rice's Brook. Limited in frequency, the County sampling showed total phosphorus and nitrates readings that were elevated on occasion.

For example, nitrate levels for Amber Creek taken during the spring of 1994 (April and June) were 1.4 mg/l and 1.1 mg/l, respectively. For total phosphorus the October, 1993 measurement at Van Benthuysen Creek was 3.3 mg/l. The April 1994 reading was .08 mg/l for both Van Benthuysen and Amber Creek. None of these measurements were made at very high flows.

Water Quality - 1990s (Cont.)

The NYSDEC recently completed a cursory limnological sampling of Otisco Lake as part of the Department's first overall assessment of the Finger Lakes in more than two decades. Data results from August 1997 show that no discernible changes have taken place in Otisco Lake with the lake still being best characterized as mesotrophic. For example, the August 14, 1987 total phosphate (as P) measurements were 16 and 10 ug/l for the epilimnion and hyplimnion, respectively. This is very similar to average total phosphorus values reported by UFI (1989) during 1986 (13.7 ug/l) and 1988 (17.0 ug/l).

CHRONOLOGY: ISSUES AND CONCERNS

Since the early 1980s, Otisco Lake residents have raised water quality related concerns. Drinking water quality issues have been the impetus for most of the initiatives and protection measures put forth over the past two decades. However, a number of other lake concerns have arisen over the years that required attention.

In the early and mid-1980s, many residents were concerned over low lake levels with many residents feeling that OCWA was withdrawing too much water from the lake. Lake level concerns diminished with the return of more normal precipitation patterns. Around this same time period, a number of residents were concerned that the OCWA watershed inspection effort was not rigorous enough. As improvements were made in the program, concerns subsided to a great extent.

Concern over excessive macrophyte (aquatic weed) growth in the mid -1980s lead to a two year (1986-87) contracted aquatic weed harvesting effort. This program included a pre- and post-harvesting survey to help assess the impact of harvesting. Algae blooms of a magnitude large enough to require OCWA to treat Otisco Lake with copper sulfate for drinking water taste and odor prevention are not very unusual. However, blooms of a magnitude large enough to result in aesthetic or similar nuisances have been very infrequent.

More recently, site-specific concerns over the presence of excessive aquatic vegetation have occasionally been raised. Shoreline property owners have become increasingly concerned with shoreline erosion. A potentially greater concern is the established presence of zebra mussels. OCWA had previously taken preventive steps by constructing intake chlorination feed system. This has eliminated, or at least severely curtailed, any impact that zebra mussels might have upon public water supply and treatment. However, concern over what the possible impacts are to shoreline residential water lines and lake ecology remains.

REMEDIATION AND MANAGEMENT

Drinking Water Supply/Lake Turbidity

The list of remediation and management initiatives that have been implemented at Otisco Lake and within its watershed is extensive. Although discussed and conceptually evaluated for some time, the Onondaga County Water Authority (OCWA) Filtration Plant began operation in 1986 and addressed the drinking water portion of the turbidity issue. Improvement in the lake's turbidity problem was realized through reconstruction improvements made to the Causeway. These improvements helped curtail movement of shallow turbid waters northward from the southern or Mud Lake portion of the lake.

The OCWA watershed inspection program continues to play an integral role in watershed protection. In addition to its extensive drinking water supply monitoring, OCWA collects weekly dissolved oxygen and temperature profile data during the summer season for long-term comparative purposes. Algae samples are taken on a weekly basis during the open water season with collections made at four surface locations along the lake including a profile sample near the intake.

Agricultural Best Management Practices

Agricultural nonpoint source remediation and management efforts have focused on nutrient and sediment source controls in this largely agricultural watershed. Federal, state, and local funds have been made available fo. project implementation over the last fifteen years. Most recently, federal funds through the U.S. Environmental Protection Agency (USEPA) have been targeted for the Otisco Lake watershed in conjunction with the Environmental Quality Incentives Program (EQIP).

Through the U.S. Natural Resources and Conservation Service, the EQIP combines with the overall Agricultural Environmental Management (AEM) process to implement sound best management practices (BMP's) on farms. The cost-share rate under this agricultural program is 95% on most eligible practices identified in the assessment stage. Approved agricultural streambank stabilization projects are funded at full-cost. The Onondaga County Soil and Water Conservation District (SWCD) implements the AEM program in the watershed. A farmer advisory committee has been established by the District to help guide the program.

A multi-agency monitoring effort involving the USGS, New York State Department of Health (NYSDOH), Onondaga County SWCD and the Onondaga County Health Department was initiated in the fall of 1997 on a farm in the Spafford Creek subwatershed. The project will assess the level of water quality improvements that can be obtained from implementing agricultural BMP's.

Public Education

Earlier public education efforts focused on the development of educational materials by the Onondaga County Water Quality Management Agency (WQMA) along with their distribution by OCWA during its watershed inspection program. Brochure topics included: septic system operation and maintenance, good homeowner practices to protect water quality, and explanations of the Otisco Lake Watershed Rules and Regulations. Copies of the Otisco Lake Watershed Rules and Regulations are also distributed by OCWA. These materials are still provided on an as-needed basis.

While not specifically intended as such, the OCWA Otisco Lake Watershed Inspections Annual Report also serves as a public educational vehicle. The Reports summarizes the annual inspection activities. Included is the census information from the watershed agricultural and waste disposal systems surveys, the number and type of violations found, and a tabulation of the various water quality analyses performed.

Recent public education efforts have focused on the creation of a comprehensive informational guide called the "Otisco Lake Book". Modeled after a similar publication for Keuka Lake, the Otisco Lake version is being produced by the Onondaga County Cornell Cooperative Extension through multiple funding sources. The Otisco Lake Book will be distributed to watershed residents this summer by OCWA watershed inspectors and at the Otisco Lake Community Association annual meeting/festival in July.

Another recent public education effort has been the Extension's "Home-A-Syst". Begun in the spring of 1997, this program provides one-on-one assistance to lakeshore residents interested in implementing practices on their property that will minimize water quality degradation. Residents learn about proper practices for maintaining septic systems, protecting individual drinking water supplies, and how to control erosion and runoff from their residential properties. The program will continue through the summer of 1998.

In 1996, the Cooperative Extension established the Skaneateles-Otisco Lake Educational Advisory Committee. The Committee's objective is to identify pubic education needs for the residents of their respective watersheds. This objective is detailed in the Committee 's mission statement which is to:

"...raise awareness of the impacts that individuals have on their ecosystem. We are enhancing people's knowledge about watershed issues in the hopes that they will be inspired to take responsibility for stewardship of their land, their water, and their communities."

Two workshops were held through Extension in the watershed last year. The first was a private well/septic system workshop, which included a discounted nitrates and bacteria residential well water test. The second session, held at an Otisco Lake Community association meeting, included technical and information presentations by speakers from the Onondaga County SWCD, Cornell University, and New York State Sea Grant. The subjects discussed included: agricultural best management practices, shoreline erosion protection, and aquatic vegetation control methods.

AEM process, and 4) Otisco Lake Watershed AEM Project

Public Education (Cont.)

There is also an agricultural public education component to the Otisco Lake watershed AEM Program. A current focus of the program is to increase awareness in the non-farm community of the water quality stewardship practiced by watershed farmers and to show how the community-at-large benefits from agricultural management efforts by having an important public drinking water supply source protected.

A workshop was held in the spring of 1998 for the watershed farmers and general public. Presentations included information on the following: 1) the Onondaga Lake watershed, 2) SWCD Best Management Practices-Demonstration sites within the watershed, 3) the AEM process, and 4) Otisco Lake Watershed AEM Project progress.

Otisco Lake Tributary Data 1991-94

Onondaga County Health Department

Parameter Mg/l unless noted	Amber Creek					Van Benthuysen Creek					Rice Creek	
	Nov21 1991	Oct21 1993	Apr26 1994	Jun16 1994	Oct28 1994	Nov21 1991	Oct21 1993	Apr26 1994	Jun16 1994	Oct28 1994	Jun6 1994	Oct28 1994
Flow (cfs)	11	10	---	---	---	19	25	---	---	---	---	---
Nitrate	.66	.4	1.4	1.1	.7	.64	.9	.8	1.1	1.2	1.8	1.3
TKN	---	<.5	---	4.7	<.5	---	<.5	---	1.4	<.5	2.9	<.5
TP (ug/l)	<20	60	80	<20	<20	<20	3300	80	20	<20	50	<20
TSS	<4	2	---	---	21	<4	<1	---	21	2	46	6
Chloride	25.7	420	---	---	---	---	130	---	---	---	---	---

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RECOMMENDED ACTIONS

- **Information Exchange/Coordination**

1. An extensive array of quality protection initiatives is being undertaken in the Otisco Lake watershed. These efforts are efficiently implemented by the respective entities. However, benefit could be derived from a collective discussion of the more recent activities of the involved agencies. A format for such an information exchange could be an Onondaga County Council on Environmental Health meeting devoted to the Source Water Assessment Program (SWAP) and County Water Quality Strategy updating process.

2. Otisco Lake should remain in the Finger Lakes Lake Ontario Watershed Protection Alliance (FL-LOWPA) five-year sequence review of watershed management perspectives and progress. Organized in conference format, discussions provide information exchange and a means for assessing progress towards desired watershed goals. The next Eastern Finger Lakes sequential review, which would include Otisco Lake, is scheduled for 1999.

- **Intermunicipal Communication**

3. Local watershed municipalities need to be kept apprised of issues of both interest and concern to these entities. Such interaction has been maintained by OCWA. Several agencies work cooperatively with watershed municipal highway departments on drainage, runoff control, and similar projects that provide water quality protection benefits. A more formal mechanism for municipal interaction is not needed at this time.

- **Monitoring Data, Collection and Reporting**

4. There is no indication that the limnological condition of Otisco Lake has changed. However, it has been over a decade since the lake was intensively monitored and even longer since watershed loadings were assessed. Completion of a comprehensive monitoring assessment to provide a comparison to data findings from the 1980s would be beneficial. This would include both lake and tributary monitoring components.

5. The long-term monitoring efforts should continue with some cost-effective additions including secchi disc readings and more comprehensive tributary sampling. Transparency data may become particularly useful with the recent establishment of zebra mussels in Otisco Lake.

- **Monitoring Data, Collection and Reporting (Cont.)**

6. Sufficient water quality data exist to provide for an expanded discussion of the water quality conditions summarized in this Framework. This information should be synthesized into a more detailed format to serve as a " State of Otisco Lake" Report.

- **Agricultural Watershed Protection**

7. Continue the AEM program that addresses agricultural sources of nonpoint source pollution through the implementation of best management practices.

8. Continued monitoring of Best Management Practices to determine their affect on water quality.

- **Public Education and Community Outreach**

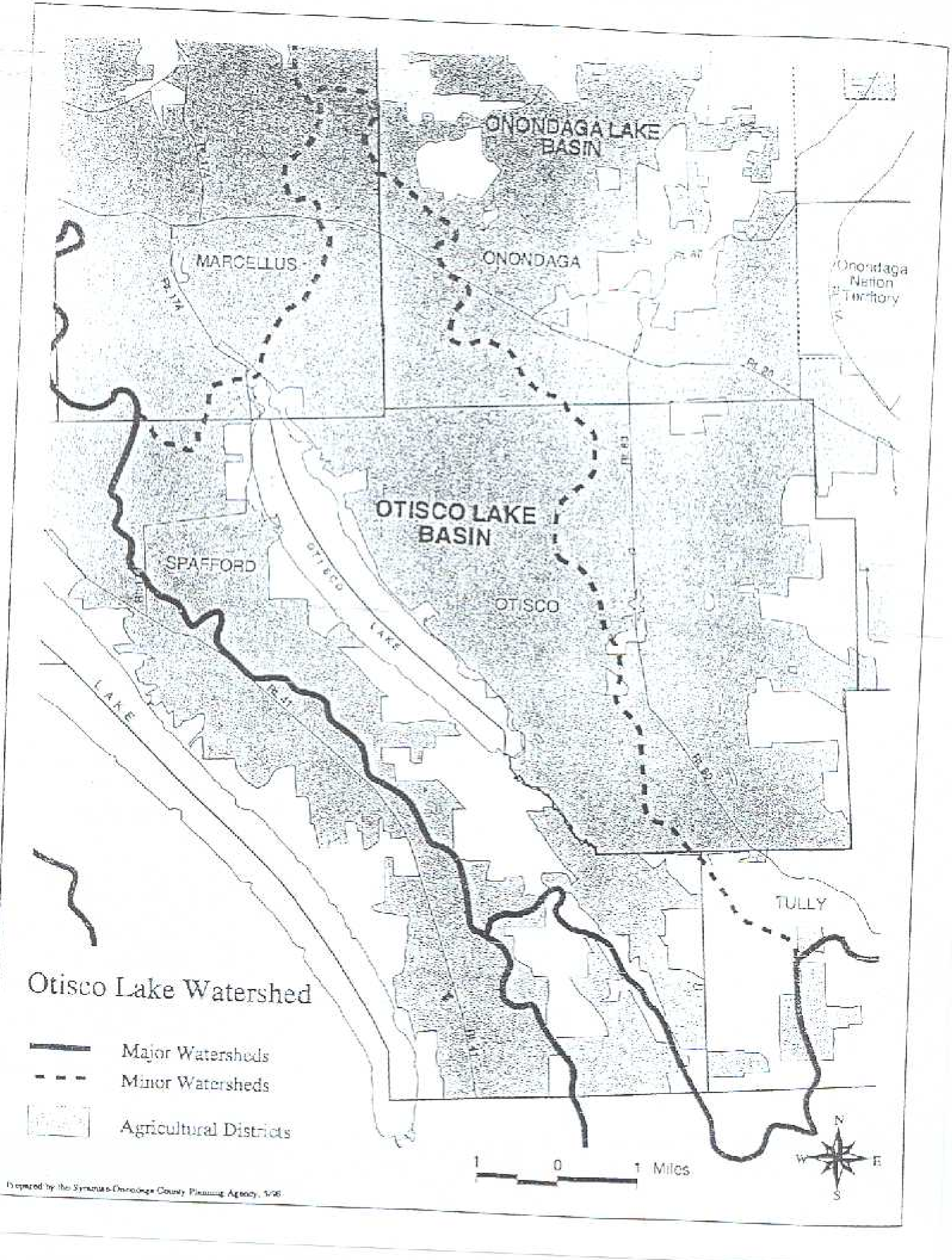
9. The Otisco Lake Community Association presently appears to be the most logical vehicle to obtain public input from as well as to provide educational outreach on Otisco Lake water quality and other lake-related issues of concern to residents. Recent Community Association sessions organized by the County Cooperative Extension that focused on topics of specific interest to lake residents should be continued, as needed.

10. Ensure maximum outreach for the EQIP program initiatives aimed at enhancing the general public's understanding of the agricultural community efforts to protect the Otisco Lake drinking water supply as a benefit for all Onondaga County residents.

11. Continue to stress through public education avenues individual homeowner and property owner initiatives and responsibilities to protect water quality by, for example, septic system maintenance, shoreline erosion protection, judicial or alternative pesticide, herbicide, and fertilizer usage.

- **Public Access**

12. Any improvements in public access should provide additional recreational and/or leisure opportunities that are compatible with existing lake uses.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Onondaga Nation Territory
OTISCO LAKE BASIN
SPAFFORD
OTISCO
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TULLY
Otisco Lake Watershed
Major Watersheds
Minor Watersheds
Agricultural Districts
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Prepared by the Syracuse-Onondaga County Planning Agency, 3/98